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Roadbeds and Tractive Effort.

It is singular that in spite of the long distances of our country and the importance of communications, road building has not made further progress and that road using is still imperfectly understood. It may be, perhaps, that every community thinks itself likely to become an important railway center and so neglects its humbler thoroughfares. But for purely economic reasons there comes a period at which railroad building must cease, and the ordinary roadway must be the sole reliance. Any one who spends even a summer in the country comes fully to realize the waste of energy and the needless effort demanded by even fairly good roads. The condition is obviously bad, but how bad it is difficult to estimate. The desirability of a thorough experimental study of the question is manifest. Up to the present it has been very difficult to get accurate data. To-day, in the age of motor vehicles, there is for the first time chance for the proper investigation of the whole situation. It would not be a difficult matter to fit up the chassis of a motor car with a grade and speed recorder and with a dynamometer in the transmission gear, thus making for ordinary roads the equivalent of the testing car that has proved invaluable in railway practice. Starting in work with such apparatus it would be easy to get a closely approximate idea of the real tractive effort per ton at various speeds and on various sorts of road in different conditions of surface.

The data thus obtained would directly pertain to motor vehicles which will every year become a more and more important factor in general transportation. It is well known that upon railways the driving wheels appear to have a frictional relation different from the rolling wheels. Doubtless a similar difference, probably greater in degree, will be found in the case of motor cars. But any kind of a vehicle carrying any reasonable load can readily be towed behind such a testing car as we have in mind, and with a dynamometer in the tow line data can be obtained with any kind and width of tires, for any kind of roadbed. With a motor car the speed can be held uniform and good experimental conditions obtained, which is nearly or quite impossible in experiments with animal power alone. The information thus obtained would be of great practical value in road location, road building and vehicle design. The ratio between road resistance and grade resistance is one of the important factors in determining how far it is economical to pass around rather than over hills. The absolute value of tractive effort on various roadbeds with various tires is the basis of any economic study of road and vehicle construction. Of course there is one very wide distinction between this problem on common roads and on railroads. In the former case the amount of traffic and the material available are of fundamental importance, while in the latter they are somewhat subsidiary since steel rails will be used in any case, and though their weight varies within certain limits the total cost of roadway is subject practically to no such variation as exists between a paved street and a dirt road.

To any one familiar with good roads abroad the average American highway is an abomination. To be sure, on the Continent roads have been evolved through centuries of use and the average traffic is much heavier than here. Still, much of the difference is the product of the last century and has come from a keener appreciation of popular necessity than is here current. The gathering of proper data is the first step in the campaign of education that leads toward improvements. Such tests as we have been considering might well be taken up by the Government as bearing directly upon agriculture, commerce and industry. It seems clear that the increasing use of motor vehicles must be taken into account in all future road building and the first step toward doing this is the determination of the working conditions. Broadly, a good road for animal traction is also a good one for motor cars, although under the latter class of traffic it may not be durable. It requires a good amount of care to keep up a macadam road against the assaults of rubber tires, and one point worth studying is the effect of a somewhat more yielding surface on tractive effort with tires of varying widths. The road of the future must be built with due regard for a mixed traffic of motor vehicles—probably heavy ones—and of ordinary vehicles. It must in consequence be laid out for average speeds somewhat greater than now customary which implies a necessity for greater smoothness of surface. At present there is very little known about the performance of road surfaces under anything but very moderate speeds, hence the greater necessity for intelligent investigation. For some years there has been a movement toward the use of wider tires which has made unfortunately little progress on account of lack of popular knowledge of their advantages. If a systematic study of traction on ordinary roads were carried out the results would prove an irresistible argument for reform and would lead to the possibility of maintaining road surfaces far easier for vehicles than those commonly in use. But the first thing is to get the data at hand. The subject is yearly of greater and greater importance and the necessity for improvement is most obvious. Therefore it is high time to get at the bottom facts.

Three-Hinged Concrete Arches.

The concrete bridge recently completed at Cleveland, Ohio, and described in this issue of The Engineering Record is deserving of special comment. It is a three-hinged concrete arch without reinforcement and its rise is unusually small. There is nothing remarkable in either the three-hinged feature or in the small rise, except that for some reason no three-hinged concrete or other masonry arch has heretofore been constructed in this country, although that type of arched structure is well known in Europe. In this case presumably the exceptionally small rise prompted the three-hinged feature, since the deflection following the removal of the centering would probably produce cracks at or near the crown of a monolithic arch if not at either extremity of the span. The hinges at the crown and springing constitute joints in anticipation of cracks and take their place as a matter of design.

Arches of such exceptionally small rise are in reality subject to no vicissitude of construction other than those which may attend arches of more usual proportions, but the tendency to crack in consequence of the initial deflection is much accentuated. In fact, the contraction of the concrete due to setting and to the low temperature of ordinary winter weather might easily result in a depression of about an inch and a half at the crown, as has been computed in this instance. It would certainly be unwise to subject concrete without reinforcement to such physical conditions except due provision be made for it by a designed joint to give the requisite relief. The prevailing foreign practice would sanction the reinforcement of such a concrete arch even with the three-hinge feature, and it would not be an extravagant procedure to introduce reinforcement although it may not be absolutely necessary. The presence of a small amount of steel in such a concrete mass as an arch affords capacity for tensile resistance sufficient to give the structure a physical unity having some substantial advantages. Cracking from any cause is much less liable to take place, and in case of an unusual unsymmetrical concentrated loading the resulting margin may not be larger than desirable even though safety may not be imperilled without it.

As a rule American engineers seem to regard the advantages of continuity in concrete structures, either reinforced or not, as controlling, and at least in the case of reinforced concrete the continuous arch structure has substantial merits of stiffness and high carrying capacity. It is true that the computations of stresses in the continuous reinforced-concrete arched rib are less well defined than those for a similar rib with three hinges, for continuity compels the use of equations based upon elastic properties of the material in the necessary computations of design. This fact introduces a little uncertainty as to the exact value of the stresses to which the continuous arch may be subjected, but the uncertainty is so small as to be negligible for all practical purposes. The advantages of simplicity in the computations of the three-hinged arch are of little practical consequence in view of the facility with which all reinforced concrete arch computations may be made at the present time. It becomes a question in either case, therefore, which type of structure can be put in place for the least cost to carry the prescribed loads. The difference in cost between the two types again is frequently so small that it becomes a matter of individual judgment with the engineer which shall be adopted for his purpose. The more cautious design may be like that of the Brookside Park bridge at Cleveland, where the hinged joints are introduced to prevent or rather to take the place of any possible cracking. On the other hand the engineer who feels greater confidence in his material would reinforce the concrete, thus gaining what he would probably consider the advantage of additional stiffness, feeling confident that if cracks appeared at all they would be too small to be observed or to effect even remotely the stability or safety of the bridge.

This particular structure at Cleveland is highly interesting as including the rather unique features commented upon. It is one of a long list of arch structures rapidly growing longer in this country, which is illustrative of the combination of grace and strength that may be incorporated in either reinforced or non-reinforced concrete arches.

The United States Reclamation Service.

Most intelligent Americans are now aware that the Government has embarked upon an undertaking for supplying water to selected areas in the Great American Desert. Projects already undertaken provide for the irrigation of approximately one and one-half million acres of the nearly one and one-half million square miles of arid or semi-arid lands in the continental portion of this country, at an estimated cost, ranging from $20 to $30 per acre. It is also somewhat generally known in an indefinite way that substantial progress has been made in the surveying and determining of projects and the designing and constructing of works. Few, however, especially in the East, have any adequate conception of the vastness of the territory over which these operations are spread, of the natural and human difficulties to be overcome, and of the methods employed. Still fewer are those who have seen any of the works or even read accurate descriptions of their details. Indeed, a very limited number of engineers have opportunities to visit any of the projects, which, from their very nature, are usually far removed from the common lines of travel and comparatively inaccessible.

Back in the seventies, Major J. W. Powell began a campaign of education on the irrigation of the western arid lands, which in the course of time resulted in the establishment of the division of hydrography of the Geological Survey, extensive surveys, the collection of many data relating to the different aspects of the problem and ultimately in the passage of the reclamation act, which was approved June 17, 1902. By this latter date, the operations of the hydrographic division had produced a body of engineers well seasoned in the conditions and requirements of the region in which the reclamation work was to be done. From this body was selected a chief engineer and a small staff for the new service, and on this foundation has been built the large organization now directing operations in eleven states and three territories, extending from the Mexican to the Canadian line and from the Missouri River to the Pacific Ocean. Preliminary studies are in progress also in one other state and territory. This organization has been selected and assembled under the restrictions of the United States civil service, with strict regard for individual and collective efficiency. How well Chief Engineer F. H. Newell has succeeded in this part of his task is indicated not only by the size of the organization gotten together in a short time, but more especially by the personnel of this body of men, drafted from the East as well as from the West. To those who have the pleasure of extensive and intimate acquaintance among the engineers of the Reclamation Service, the high character, energy and enthusiasm of the responsible men are well known. With such leaders it follows that the rank and file are animated by a commendable spirit.

With its glorious and dependable sunshine and sense of boundless freedom, the great desert has a powerful fascination. But the dust is ever with one and the separation from the more liberal advantages of the populous regions grows irksome to some of the men and especially to their families. In the Southwest, too, the heat is enervating. Realizing the disadvantages, special efforts have been put forth to render the camps comfortable and attractive. At moderate cost many of the comforts of civilized life have been provided. Neat cottages, substantial tents and commodious bunk houses have been built. Good water supplies have been procured. Artificial ice plants and electric lights have been installed wherever feasible and necessary, and many of the camps have more or less of modern sanitary plumbing. Housekeeping problems have been partially solved by the establishment of central mess houses. Even means for recreation have not been forgotten. Telephone and telegraph furnish speedy communication and the mails bring a variety of reading matter.

At the headquarters in Washington there is a considerable force engaged upon legal matters, auditing and cost keeping, disbursing and accounts, general drafting and reproduction of drawings, correspondence and records, departmental matters and the general executive direction of the work. The field is divided into districts, each embracing a state or territory, or two or more states or parts of states, according to the magnitude of the projects. In charge of each district is a supervising engineer, who perforce of circumstances has nearly the independence and responsibility of a chief engineer on less scattered systems of works. Under the supervising engineers are engineers in charge, or project engineers, with their staffs of assistant engineers, engineering aids, clerks and laborers residing at the several projects. Connected with the service are a number of consulting engineers and specialists. New projects and the more difficult problems of projects in progress are referred to boards of three or five members drawn from the consulting and supervising engineers. Reports of these boards form the basis of the decisions of the chief engineer. Associated with the chief engineer is an assistant chief engineer, who spends the greater part of his time in the field, but Mr. Davis, who holds this office, also relieves the chief engineer at Washington, and thus makes it possible for the latter to be in the field part of the time without detriment to affairs at headquarters.

The broad and intelligent spirit with which this great undertaking is being administered is well set forth in a few sentences taken from one of the annual reports of the chief engineer. "It is recognized that there are necessary limitations in governmental work. Efforts are made, however, not only to comply with the spirit of the law, but to execute the work economically and well, and, general authorization having been obtained, to proceed without loss of time. This is a matter of fundamental importance in conducting work in remote localities, since precise insistence upon minute regulations would inevitably lead to the tying up of operations and to the wasting of large sums of money while definite orders are awaited or problems of official routine are solved. In order to permit responsible men to transact business rapidly and economically it is necessary to give them general instructions and to hold them to the prompt and effective accomplishment of results, the work not to be delayed by the necessity of applying to Washington for every step in the proceedings. At the same time it is insisted that care be taken to avoid entanglements growing out of the short cuts, which, while feasible for individuals, are prohibited by laws or departmental regulations." And this policy does not exist merely on paper. Wherever the common sense path is clear and safe, desired results are accomplished, and the red tape unsnarled or cut at leisure subsequently.

Four years and a quarter have passed since the reclamation law was approved. To those waiting for water, time, heavy-footed, may seem to run with the snails; but, remembering the conditions, commendable progress has been made. Not only has the large organization been created and equipped and a great amount of preliminary work been done, but about 110 sets of contract drawings have been published, the work advertised and the contracts let. Unfortunately, like some other great enterprises, the Reclamation Service has been annoyed and delayed by contractors failing and abandoning their work, on account of too low bidding or for other causes. Some large pieces of work thus abandoned are being successfully carried on by the engineers on a force account basis. Much of the work is being done under comparatively untried conditions, and, as is not all strange, human judgment and prediction have sometimes erred. It has been difficult to get enough good men for both engineering and construction forces; suitable laborers have been especially scarce. In the Salt River valley and adjacent territory the Apache Indians have proved the most reliable and satisfactory laborers, incredible as this may seem to those who still think of the Apache only as he was twenty years ago. Not only on Government work but on the railroad construction also, he is the mainstay. He can not only dig, but can make good concrete under proper supervision. Elsewhere other Indian tribes furnish a few men, but they are not very useful. In Nevada "hoboes" were about the only species of common labor to be had, and, true to principle, individuals of the clan did not tarry long, so that the force was continually changing.

In spite of these discouragements much good work has been done which will not suffer at all by comparison with works executed under much more favorable circumstances. Indeed, the concrete work is excellent. To mention only one example, in the line of the Salt River power canal there are two reinforced concrete pipes 5¼ ft. in diameter, over 500 ft. long, under 85 ft. head, which have been in service for about a half-year and have so small a leakage that it cannot be measured. In the same line there are also two similar pipes about a half-mile long under a head of 30 ft., equally successful. The main parts of the Truckee-Carson project in Nevada, are so far completed as to be in service. In Colorado the Gunnison tunnel, 30,582 ft. long, is more than half excavated. On some of the northern projects likewise substantial progress has been made, although in general the largest of these works are only in the earliest stages of construction. Cement is being manufactured at the Roosevelt plant at a moderate cost. So far as this journal has information the works are being constructed at a reasonable cost, especially when the unusual difficulties, the scarcity and high price of labor and the short legal working day are taken into consideration.

When it is understood that the engineers of the Service have been invading hitherto practically inaccessible places, the necessity for some skillful and startling road building and other unusual preliminary works is not a surprise. The drive over the road in the Salt River Canyon is worth a long journey, and the 20 and 25 per cent. grades by which the latter part of the descent into the Grand Canyon of the Gunnison is effected will afford a tenderfoot some sensations which he has not experienced on his boulevards at home. The almost level runs across the broad deserts, with the thermometer around 150°, have peculiar pleasures, also, for the novice.

With a conservative policy, avoiding over-development of any water supply, careful examination of all the features of each project before it is undertaken, and a continuance of the present efficient direction and methods, results of which the country may rightfully be proud can be reasonably expected. In no small measure the success of the enterprise hitherto is due to the efforts of the Director of the Geological Survey and the Secretary of the Interior, who have much facilitated the departmental details.

Zinc in Boilers.

The suspension of zinc in boilers to prevent corrosion of the water surfaces was formerly a general practice and has not yet been entirely abandoned. That the supposed remedy has ever had any efficacy is a matter of doubt, from the standpoint of both theory and practice, though the circumstances accompanying its adoption, as noted below, may have fully justified the practice when initiated. The introduction of the surface condenser into marine practice was accompanied by a remarkable deterioration of boilers, which gave rise to so much concern that the British Government appointed a Royal Commission to investigate the causes and propose a remedy. This Commission consisted of engineers, boiler manufacturers, metallurgists and scientists, including one representing electricity, and the result of their exhaustive researches was published in several large quarto volumes. The conclusion ascribed the prime cause of the deterioration to the brass tubes of the surface condenser, but the destructive effect was assigned to one or both of two distinct actions, one electrical and the other chemical. The electrical effect, if any, was held to be due partly or wholly to local electrical action between the iron and particles of brass carried over from the condenser tubes to the boiler, and partly or wholly to local electrical action between portions of the boiler metal in different physical states. On the other hand, experiments indicated that the pitting could be entirely due to chemical action arising from the grease and tallow then used to lubricate engine cylinders. The final recommendations of the committee were, first, that the tubes of surface condensers should be tinned where they came in contact with water entering the boiler; second, that zinc should be suspended in the boiler; and third, that only a mineral lubricant should be used in the cylinders of engines exhausting into a surface condenser. These recommendations were quickly carried into practice, with the result that abnormal boiler corrosion immediately ceased. Unfortunately, the simultaneous adoption of three different remedies rendered it impossible to differentiate the final effect, and it is quite possible that if the recommendation had merely been with reference to the lubricant the result would have been equally satisfactory.

Even if the theory as to the action of the zinc were accepted, the method of the application of the remedy was such that it could not have the effect postulated. As a primary cell, the internal resistance of the boiler would be so small that there would be a rapid generation of electrical current, with a rapid consumption of the zinc. Again, the protection afforded by the zinc would depend upon its intimate metallic connection with the boiler brace to which it was attached, and this would be impossible to maintain; in placing the zincs the instructions were to file a clean surface on the boiler detail to which they were to be wired, but observation has shown that after a very short time deposits from the water destroy the electrical contact. Moreover, the zinc itself becomes coated with an oxide or salt which prevents the free metallic contact with the electrolyte necessary for electrical action. In one case a leaky gasket rendered it necessary for a boiler which had just been provided with new zincs and in which steam was being raised, to be cooled down and opened, and it was found that in the half hour or so during which fires had been lighted, the zinc had become covered with a coat of an oxide or salt insoluble in water which would prevent action of the electrolyte with the metal. Even on the old theory that the connection of one metal with another would render that which was electro-negative passive to electrical action, the effects above noted would preclude any benefit. In order to determine the working result of this practice, at one time the boilers of a part of a fleet were not supplied with zinc, frequent reports were required for all vessels on the subject of boiler corrosion, and the result of the comparative test was that the practice of installing zinc in boilers was in this case terminated. To sum up, the suspension of zinc in boilers as a means for the prevention of corrosion of boilers lacks the support of theory and is not justified by the results that have been obtained in practice.

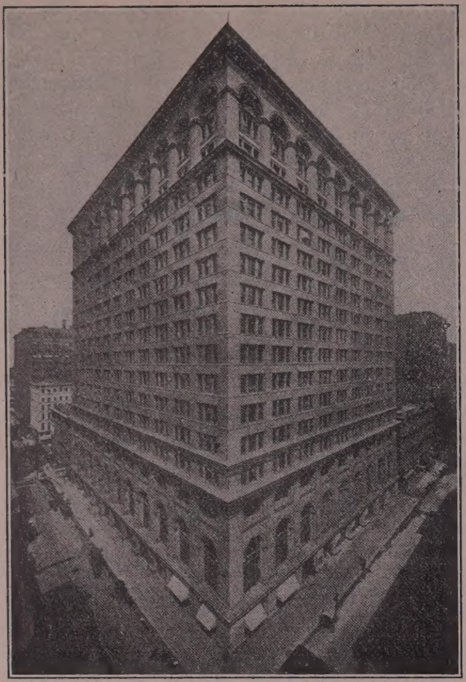
Notes and Comments.

A Reinforced-Concrete Bridge having thirteen spans of 54 ft. on centers of piers or 50 ft. in the clear has recently been completed over the Hawkesbury River at Richmond, N. S. W. Its total length is 722 ft. The roadway is 21½ ft. wide between the handrails, which can be folded down into recesses prepared for them in the curbs in order to be out of the way when the bridge is submerged by floods. Each pier rests on concrete caissons, and the upper one is anchored to the bed rock by iron rods. The arches are of the Monier type, designed to resist flood pressure as well as vertical loads.

The Collapse of Concrete Buildings at Mineola, N. Y., Lockport, N. Y., and Elyria, O., early in the month affords proof of the statements often made in this journal concerning the necessity of knowledge and good judgment on the part of everybody connected in a responsible capacity with each stage of the design and construction of such works. The long list of failures of iron and steel bridges and building frames has not resulted in any diminution of the number of such structures, and the occasional fall of a concrete bridge or building will not signify any halt in their erection. These accidents afford lessons concerning the things to be avoided; they teach the owner to employ good designers and contractors and to avoid pushing the work so that the concrete is only imperfectly hardened when the forms are removed, and they teach the designer and contractor many technical lessons it is hardly necessary to enumerate here. At the present time is seems that the owner is generally the man responsible for the failures, owing to his unwillingness to employ competent specialists to design and build the structures and his insistence on hurrying the work more rapidly than considerations of safety warrant. The danger of collapse with concrete works designed or erected by incompetent men is much greater than in the case of timber, masonry or steel, and for this reason the owner runs great hazards unless he employs competent men and follows their advice. But if he insists on good designs, materials and workmanship and is willing to allow the work to proceed at a rate which does not exceed safe limits, however slow they may seem to him, there is no greater reason for anticipating failure with concrete than any other material.

An Experiment in Dust Prevention is being made on a road near Troy, N. Y., by State Engineer Van Alstyne, which is attracting much attention in that vicinity. The road runs through a village of considerable population where the dust has been very annoying. To lay it, tar of about the consistency of molasses when cold and fluid when heated, is sprinkled over the road surface. The low spots in the road are then filled with screenings, which are consolidated by the traffic before the second application of the tar is made. This process is repeated a third time, and is said to result in a practically dustless highway, which will not need another treatment for a year or more. The tar employed is specially prepared for the purpose by boiling until all its water has been driven off, so that it is not likely to foam when heated for application to the roads. This road is much used by motor cars, whose owners found the dust as unpleasant as did the local residents, and consequently automobilists are watching the experiments carefully. The extraordinary increase everywhere in the number of motor cars of late has made the suppression of dust as important to their drivers as to residents along the roads frequented by them. Formerly the automobilist did not appreciate what a nuisance this dust was, but now that many cars are running over each good road there is no longer any tendency to deny that these vehicles are responsible for a somewhat serious action on the surface of the highway, and that steps should be taken to prevent it. It is not wear in the usual sense of the term, but rather suction, and as its effect can be checked by the same means that are used to lay dust, the importance of these experiments can be readily appreciated.

The Fire Test of Concrete Columns described elsewhere in this issue adds somewhat to our definite information regarding the resistance of concrete to high temperatures. In this respect the article is of value, but as regards the conclusions drawn from the tests by the author of the contribution considerable divergence of opinion is possible. No high-heat test of concrete is worth very much as a criterion for all concrete if the aggregate employed in the mixture is ordinary limestone. There are a few grades of limestone that have shown fair resistance to high temperatures, but the ordinary stone of this class disintegrates very rapidly when exposed to heat. For this reason, no concrete specialist would willingly use limestone concrete as a material to resist high temperatures, any more than a bridge specialist would willingly use cast-iron in one of his structures. Limestone concrete, like cast-iron, is an admirable material for a wide range of purposes, but conclusions drawn from fire-tests of it are likely to be as misleading as conclusions regarding the tensile strength of all grades of iron and steel, which are based on tensile tests of cast-iron. If a concrete of the highest degree of fire resistance is required, trap or cinder is employed, although few engineers will hesitate to use limestone concrete columns in buildings intended for most purposes, particularly those where sprinkler systems are installed. It is only necessary to increase the dimensions of the column required by the calculations an inch or two in order to provide pretty good fire protection.



The First Na'ional Bank Building, Chicago

Mechanical Plant of the First National Bank Building, Chicago.—1.

A sixteen-story steel-cage office building has recently been completed for the First National Bank of Chicago, which occupies a ground plan of 195 x 230 ft., at Dearborn and Monroe Sts., and reaches over 200 ft. above the curb. The exterior of the building has been simply treated in granite, while the interior has been beautifully decorated, involving a very liberal use of white marble, over 5,000 tons of this stone having been used. In the corridors of the office portion above the banking section over three miles of marble wainscoting, 7 ft. in height, was used, the cost of this detail alone having amounted to nearly half a million dollars. The banking offices occupy the lower portion of the building to the third floor, the remaining floors to the fifteenth inclusive being devoted to rented offices. The sixteenth floor has been fitted up for the use of the Mid-day Club, with kitchen and dining-rooms, while an attic floor above is devoted to ventilating machinery. The building has an interior court above the third story, 60 x 90 ft. in size, around which the offices are arranged in the form of a hollow square. The side divisions of this portion average 65 ft. in width, and through the center of all of them is an 8-ft. corridor which encircles the entire floor.

The basement space, containing about 40,000 sq. ft. of floor area, is devoted in part to the mechanical plant of the building, the central portion of the front side being utilized for the safety deposit vault of the bank, and the front corner for its storerooms and general storage purposes. The mechanical plant embraces a boiler and power plant equipment of 1,855 h.-p. capacity, the electrical generating plant supplying the current for lighting and power purposes throughout the building, an elevator installation for the operation of 22 elevators, a refrigerating plant for drinking water and general cooling purposes, and an extensive heating and ventilating equipment. The boiler equipment is located in a 60-x-120-ft. room at the rear corner of the sub-basement, at the rear of which is the coal storage vault, 16 x 120 ft. in size opening toward the firing floor. The boiler auxiliaries are contained in a 28x60-ft. section of the engine-room adjacent to the boiler-room, and the engine-room, 60 x 75 ft. in plan, is located in the front corner of the basement on the Dearborn St. side. In the center a 64x175-ft. space is occupied by the safety deposit vault, pneumatic-tube room for the bank and a barber shop, while the remaining 75 x 210 ft. space at the front corner is devoted to bank storerooms.

The steam plant consists of five 370-h.-p. Stirling water tube boilers, which are placed in individual settings in the middle of the boiler-room and have an 18-ft. firing floor between them and the coal vault. The latter was located in the space beneath the 16-ft. alley at the rear of the building and being provided with five coal holes built in the roof of the vault, coal may be dumped directly from wagons to the storage space. The forward 100 ft. of the vault is used for coal storage, which has a capacity of about 500 tons, while the remaining 20 ft. at the rear corner is reserved for ash storage and contains a hydraulic sidewalk lift by means of which ashes in cans may be raised to the alley level for removal. There is, however, a feature to be noted in this plant in the connection which has been provided for receiving coal and the removal of ashes and refuse by the freight subway system, which has been constructed under the streets in the central business portion of the city, a branch of which system has been extended to this building. The entire coal supply is received in this manner and the greater part of the ashes also thus removed. For the handling of coal from the subway up to the storage vault, a special conveying system has been installed, a description of which was presented in an article on coal handling in the Chicago subway, in the Engineering Record for March 31, 1906.

The boiler plant has an aggregate capacity of 1,855 h.-p. Each boiler has a total heating surface of 3,710 sq. ft., made up of 264 4-in. tubes, with three 30-in. x 16-ft. steam drums, and a 36-in. x 6-ft. mud drum. They are of extra heavy construction and designed for operation at 150 lb. The boilers are set singly in heavy brick settings with flush fronts, and have 18-in. x 12-ft. smoke connections to a sheet metal breeching at the rear. This breeching, which is heavily covered with corrugated vitrified block lagging, is carried overhead in the boiler-room to the rear corner of the building where connection is made to an 80-in. steel stack rising over 300 ft. to a point well above the roof line. The stack is enclosed in a 10x21-ft. pipe shaft, in which are carried also the exhaust and vapor risers to the roof and steam supply and return risers to the upper floors.

View in Boiler Room of the First National Bank Building.

The boilers are fired by Jones under-feed stokers, of which there are three fitted to each, arranged side by side, in the 12½-ft furnaces. The stokers are of the standard Jones construction with steam cylinder mechanism for feeding coal to the retorts, the coal being shoveled from steel charging cars on the firing floor to the stoker hoppers, from which the steam feeding cylinder ram forces the coal into the retorts from below as required. The retorts of this stoker are fitted with tuyeres on the side and rear through which the forced draft is delivered into the fuel bed at a point between the green fuel and that in an incandescent state—exactly where the gases are being released and the coking process is going on. The furnace space in the boiler setting is covered by a reverberatory fire-brick arch projecting out to the tube surface, behind which there are baffles which cause the products of combustion to make the three passes through the tubes before entering the breeching. With this equipment a low grade of bituminous slack coal costing $1.80 per ton is burned successfully without resulting in the production of smoke at the stack.

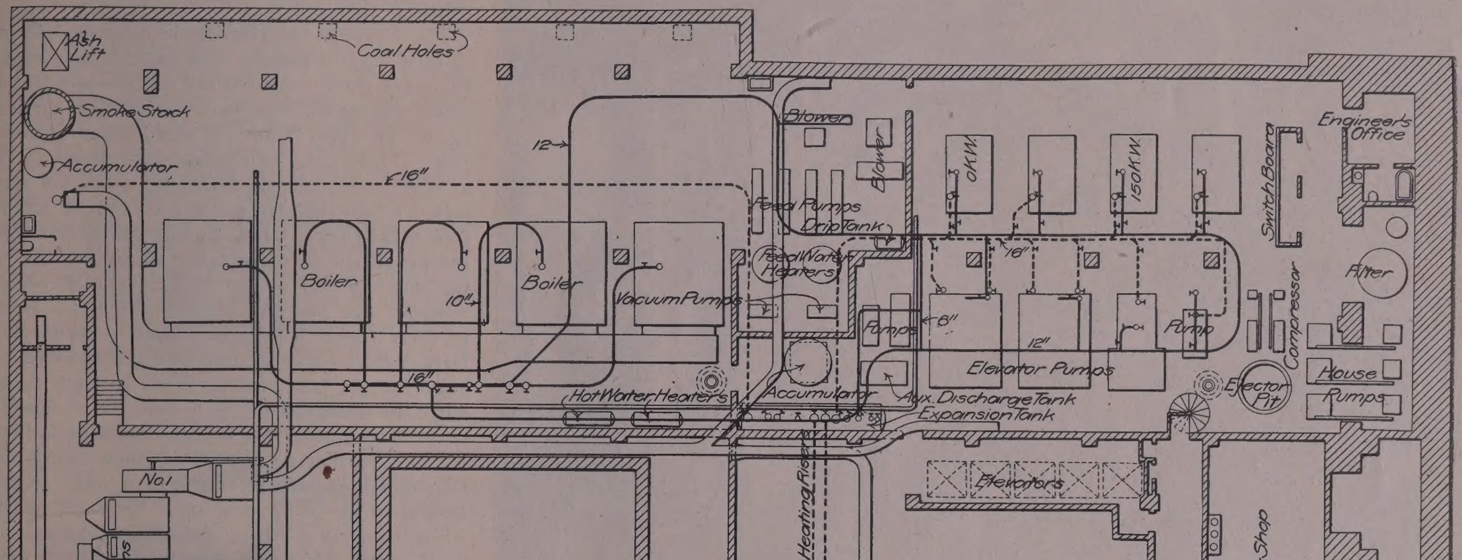
One of the interesting features of this system of stoking is the means of automatic control provided for furnace operation. By means of an automatic attachment the intervals of forward movement of the stoker ram are controlled, thereby adjusting the quantity of fuel introduced into the furnace during a given period. To supply air for combustion in quantity proportionate to the amount of fuel being consumed, and to meet changing conditions in loads, the output of the forced draft blower is automatically increased or diminished as required. This is brought about by causing the steam pressure to regulate the speed of the engine driving the blower through a Tagliabue regulating valve. This means of proportioning the fuel supply and the air supply in this manner, has enabled a practically perfect combustion to be secured, a stage in which a maximum of economy is realized, with, at the same time, a smokeless chimney. This apparatus was installed by the Under-Feed Stoker Co. of America, Chicago, Ill.

The forced draft blowing equipment is installed in duplicate, giving assurance of continuous service. One of the units is a steam-driven fan, 160 in. in diameter, consisting of a special narrow housing with a 9-ft. wheel driven by an 8x8-in. vertical marine type engine, and is capable of delivering 35,000 cu. ft. of air per minute at 2 oz. pressure per square inch, when running at 350 r.p.m. The speed of this engine is controlled by a Tagliabue pressure regulator of the Roesch type, which operates automatically from the steam pressure carried in the boilers to control the air supply in accordance with the steam demands. The duplicate equipment consists of a 110-in. steel plate fan direct connected to a 110-volt, direct-current, Crocker-Wheeler motor, having a Cutler-Hammer speed controller. Both fans were supplied by the American Blower Co. The air intake connections of both fans are arranged to draw heated air from the boiler-room above the boilers, resulting in a cool and well-ventilated boiler-room, and the forced draft delivery is made to the furnaces of the boiler by means of a trunk duct beneath the boiler-room floor, with branch ducts having valves for controlling the supply to the stoker furnaces. Each fan is capable of delivering sufficient air for the operation of all the boilers together; but they can, of course, be adjusted to meet the requirements of any number of the units operated separately.

The boiler-feeding equipment of the plant consists of four duplex brass-fitted feed pumps located in the pump room, which handle hot water from the feed heaters to the feed main. The pumps are Laidlaw-Dunn-Gordon outside-end-packed plunger pumps with 10x6x10-in. cylinders, and have their suction and delivery connections so arranged as to permit various combinations in pumping hot or cold water, as may be desired. The feed heaters are Webster open heaters, of which there are two installed in duplicate to permit of continuous service. Each is rated 1,500 h.-p. and is capable of heating the feed from 50° to 210° Fahr. with exhaust steam. A Webster vacuum line attachment from the heating system prevents them from becoming air bound, and an attached oil separator removes oil from the exhaust steam before coming in contact with the water.

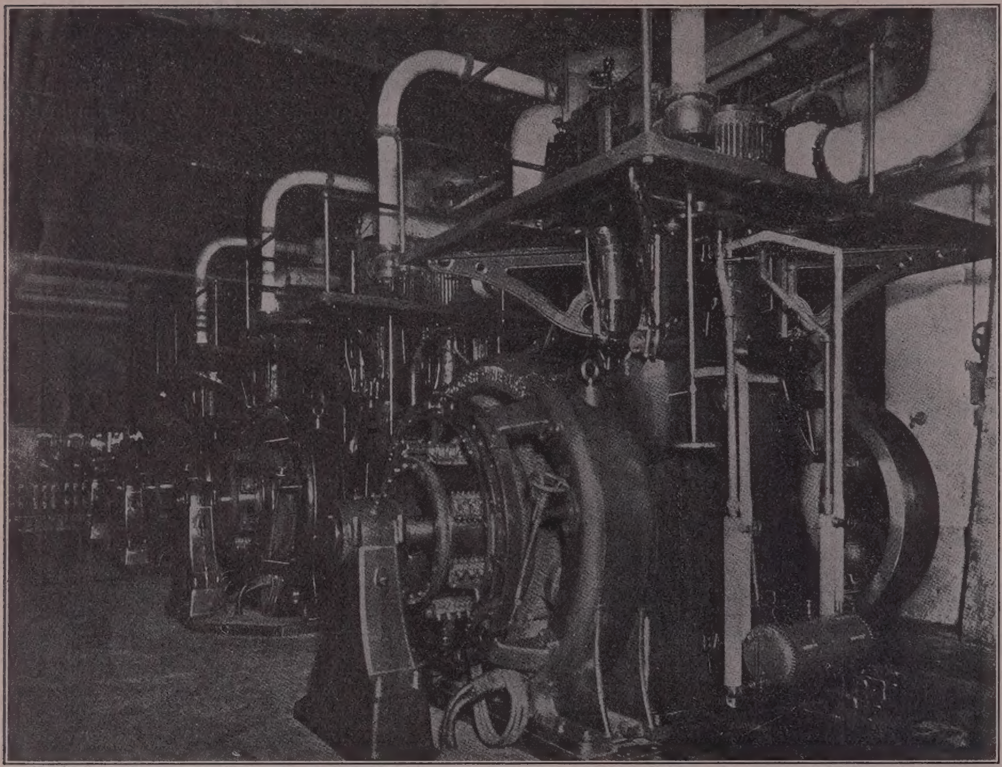
The feed piping consists of a duplicate set of 4-in. feed mains extending across the tops of the boilers, each of which has a 2½-in. branch connection to each boiler. These mains are flange fitted and so connected that either may be used, and the boiler branches to each boiler connect through stop and check valves to a common Y-fitting and a second stop valve through which delivery is made to the boiler. The blow-off system involves 2½-in. connections from the mud drums of each of the boilers, which deliver through special blow-off cocks and gate valves to a common 3-in. blow-off main at the rear of the boilers. This main leads to a blow-off basin in the rear corner of the boiler-room, which overflows into a blow-off tank alongside, containing a coil for cooling the hot discharge before entering the sewers. This tank has an 8-in. vapor connection which is carried up to an outlet above the roof.

The high-pressure steam piping system of the power plant involves an interesting ring main arrangement, involving a main 16-in. reservoir header in the boiler-room, with 10-in. branches to each boiler, from which header a ring main is supplied which encircles the engine and pump-rooms for short direct connections to all engines and pumps. The boiler-room header is of extra heavy steel pipe, with welded flange fittings from which connections are made through long radius bends to the boiler nozzles; these boiler branches have each a gate valve at the header and a non-return valve at the boiler nozzle for safety in case of accident to a boiler. The main header is divided by a sectionalizing valve near the middle, to one side of which is connected one leg of the engine-room main, while the other leg is connected to the opposite end of the header. The engine-room main is of 12-in. pipe installed with long radius bends throughout and is carried in close proximity to the throttle connec-



Basement Plan of the Building, Showing Arrangement of Power Plant and Ventilating Equipment.

tions of all steam-using machinery. For the supply of pumps and other auxiliary equipment there is an auxiliary header of 8-in. pipe connected between the two legs of the ring main where they enter the engine room, from which branches are taken to the feed pumps, to the vacuum pumps, to the pressure reducing valve for supplemental supply to the heating system and for the steam supply to the kitchen cooking apparatus.

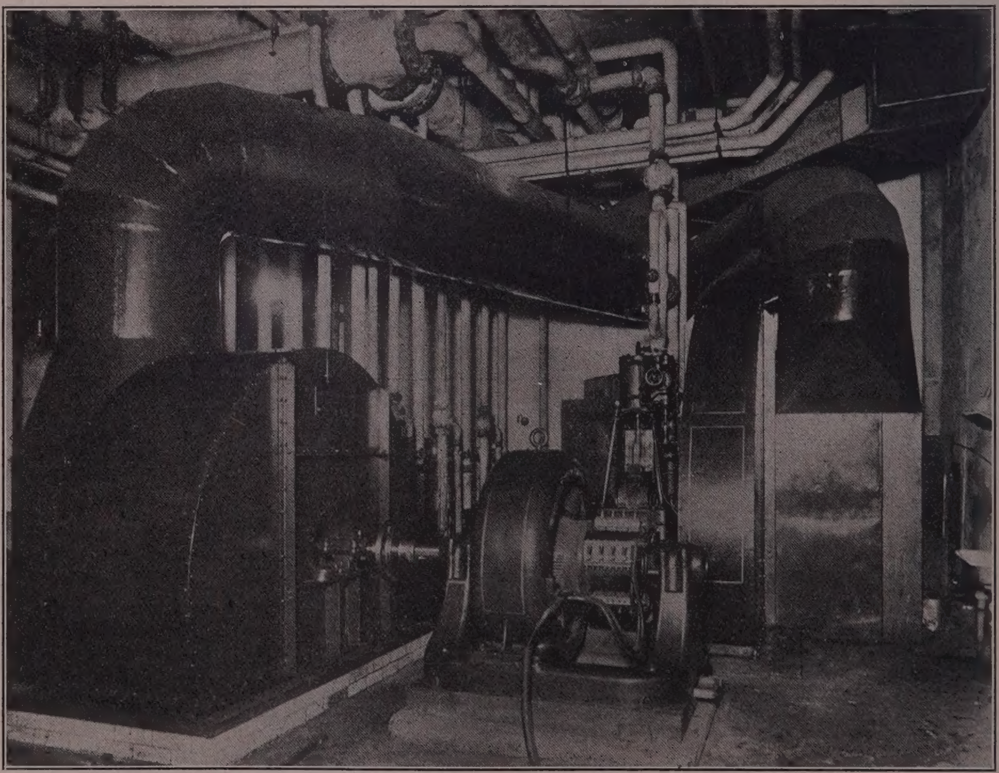


The Electrical Generating Equipment in the Engine Room.

The exhaust steam system in this plant involves a simple arrangement of suspended main with short direct connections to the various engine and pumping units, and delivery into a large cylindrical expansion tank at the rear of the boiler-room from which connection is made to the heating system of the building and to the atmospheric exhaust riser. The exhaust main is of 14-in. pipe, and has Y fittings for all branch connections. The expansion tank is a heavy steel-plate tank, 4 ft. in diameter by 18 ft. long, which is maintained partly filled with water for removal of oil from the exhaust steam. The atmospheric exhaust relief connection consists of a 16-in. wrought-iron pipe, which is carried through a back-pressure valve to a pipe shaft in the rear corner of the boiler-room where it is carried up alongside of the smoke stack, over 300 ft. to an exhaust head above the roof line. Drainage is taken care of in both high-pressure and the exhaust systems by separate drip lines, the former being trapped to the feed-water heater and the latter discharging similarly to the blow-off tank. Both the high and low-pressure piping is jacketed with asbestos air cell covering with canvas jackets.

In the engine-room are installed the electrical generating units for the power and lighting service of the building and the pressure pumps for the 17 hydraulic elevators. The generating units are four in number, each a 150-kw., direct-current generator, direct connected to a Ball vertical cross-compound engine. The engines are of the automatic cut-off type and operate at 225 r.p.m. They operate non-condensing, their exhaust being utilized for heating purposes in the building, and are guaranteed for a steam consumption not exceeding 56 lb. per kilowatt hour at half load, and 40 lb. per kilowatt hour at full load. They are designed to carry overloads of 25 per cent. continuously for two hours under which duty the speed will not drop more than 5 per cent.; while under normal loads the speed regulation is within one per cent.

For convenience of access to the cylinders and valve gear of the engines, elevated running boards are provided at a height of about 8 ft. above the floor, which have stairs for each engine and also connecting passageways between the platforms of the various engines. The engines are mounted on a continuous foundation of massive construction, which prevents communication of vibration to the building. A feature of the engine equipment is the provision of a gravity oiling system for the automatic lubrication of all bearings; the Michigan system is used, including oil filters to which the oil is returned from reservoirs and drip pans, and thence pumped to an elevated tank from which the various sight-feed cups are supplied.



The Duplicate Forced Draft Equipment.

The generators are Crocker-Wheeler medium-speed multipolar machines, designed for a voltage of 115 volts, and capable of sustaining a continuous overload of 25 per cent. for two hours without excessive heating. They are compound wound to maintain the voltage within 2 per cent. with increases of load. Connections are simplified by the use of the two-wire system of distribution throughout the building, the generators being operated in parallel by use of an equalizer connection.

The electrical distribution is controlled by a 12-panel black enameled slate switchboard, located in the front corner of the engine-room, from which the feeder lines were conveniently carried up to the upper floors by direct lines of conduit. There are four generator panels, each 24 x 78 in. in size, and containing a Weston ammeter, a field rheostat, and a 2,000-ampere, three-pole main switch. The distribution feeders are accommodated on seven panels of similar size at the opposite end of the board, each of which contains five two-pole feeder switches. Four of these panels have 1,800 ampere switches for main feeders supplying distribution feeders starting from the load center on the eleventh floor, while the remainder of the feeders are of smaller size, ranging from 100 to 1,200 amperes for individual supplies to motors, to panel boards on the lower floors and to basement circuits. In the middle of the board is a 40-in. totalizing panel, which contains a Bristol recording voltmeter, a 6,000 ampere Thompson recording wattmeter permanently connected to the bus-bars, a 1,500-ampere recording wattmeter with detachable loop connections at the rear of the switchboard for temporary connection to any feeder circuit, and Mabbs voltmeter switches with points for each of the 35 feeders, and a Mabbs voltmeter switch which may also be used as a ground detector, reading directly the loss in volts. The machine voltmeter is mounted in the usual manner on a swinging bracket hung at the end of the board.

The building is wired for 17,000 16-c.-p. incandescent lamps, and for 350 h.-p. in motors, and the average load brought upon the plant varies from 250 to 325 kw. The current furnished to each office on the upper floors, to each of the stores on the ground floor and to the bank itself is registered on recording wattmeters so that the operation of the plant may be accurately accounted for. The wiring is all installed in Loricated conduit and is designed for a maximum drop of potential between the switchboard and any lighting outlet of not over five volts.

It is of interest to note that in the operation of this plant a degree of economy has been secured which is attained in few commercial buildings. In recent tests made of the boiler equipment it has been found that the cost of evaporation of 1,000 lb. of water is less than 12 cents. In a 10-hr. economy test of one of the boilers, in which a total of 15,800 lb. of coal were burned and 373.48 h.-p. developed, an actual evaporation of 7.7525 lb. per pound of coal was secured, an efficiency of 76.1 per cent., and at a cost of $0.1104 per 1,000 lb. of water evaporated. In another 5-hr. test in which economy was sacrificed for capacity, 11,200 lb. of coal were burned and 489.77 h.-p. developed, an overload on the boilers of 32 per cent.; here an actual evaporation of 7.1629 lb. per pound of coal was shown, an efficiency of 70.3 per cent., and the cost was $0.1193 per 1,000 lb. of water evaporated. This favorable showing is due largely to the use of the low grade of bituminous slack for fuel, costing $1.80 per ton, the use of which is made possible by the stoker installation. The coal used carried 23.14 per cent. of ash.

The mechanical plant of this building was designed and its construction supervised by D. H. Burnham & Co., Chicago, Ill., who were architects of the building. The design of the mechanical features was under the charge of the late Mr. C. M. Wilkes, of this company, to whom much credit is due. The electrical installation including engines, generators, switchboard and wiring, was carried out by Mr. A. S. Schulman, electrical contractor, Cincinnati, Ohio. The heating and ventilating equipment and other mechanical features will be referred to in a subsequent issue.

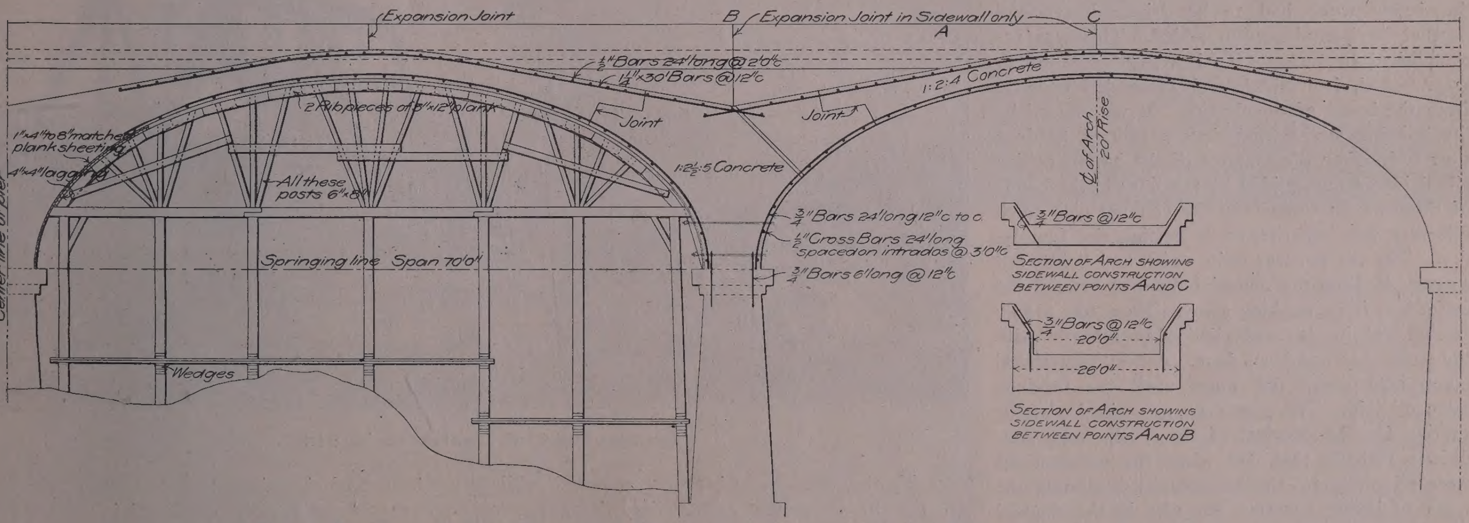
THE IMPROVEMENTS TO THE SUEZ CANAL now under way include an increase of depth throughout to 31 ft. and the bottom width to 128 ft., which will permit an increase of speed of vessels passing through it from six to nine miles per hour. This will enable ships to make the passage through the canal in 12 hours, about 6 hours less than at present.

A Four-Span Reinforced-Concrete Arch Bridge on the Southern Railway.

By H. C. Harrison.

The town of Austell, Cobb County, Georgia, is at the junction of two important lines of the Southern Ry. west of and about 18 miles from Atlanta. These two lines were formerly known as the Georgia Pacific and East Tennessee, Virginia and Georgia, and running from Chattanooga, Tenn., and Birmingham, Ala., respectively, they converge at Austell. From this point they become a single track line to Atlanta.

It will be readily seen that with two such lines as these, doing an immense through business, and both operating east of Austell, over the same track, a double-track from Austell and Atlanta would soon become a matter of necessity; therefore as soon as the Southern began double-tracking its main lines, the line between Austell and Atlanta was among the first to which attention was directed. The work was begun early in the year 1905, between Austell and Peyton, a station a short distance west of the Atlanta yard limits. East of the village of Austell, and about ¾ of a mile from it, the railroad crosses what is known as Sweetwater Creek, a stream of no mean proportions, which drains quite a large, rugged territory. This stream, on the old single line, was spanned by a steel through bridge of about 100 ft. span, resting on masonry piers and with frame trestle approaches. It was decided to carry the new tracks across the stream on a concrete bridge about 300 ft. in length and 26 ft. in width, between inside edges of bench walls. This was located immediately by the side of the old structure and so close to it as to leave but scant working space between the two. In fact, one of the piers of the new bridge and that of the old lapped about 18 in.


Expansion Joint
B
Expansion Joint in Sidewall only
C
A
½" Bars 24' long @ 2'0" c
1¼" x 30' Bars @ 12" c
1:2:4 Concrete
2 Rib pieces of 3" x 12" plank
Joint
Joint
1" x 4" to 8" matched plank sheeting
4" x 4" lagging
All these posts 6" x 8"
1:2½:5 Concrete
℄ of Arch
20' Rise
¾" Bars 24' long 12" c to c
½" Cross Bars 24' long spaced on intrados @ 3'0" c
¾" Bars 6' long @ 12" c
Center line of pier
Springing line Span 70'0"
Wedges
¾" Bars @ 12" c
SECTION OF ARCH SHOWING SIDEWALL CONSTRUCTION BETWEEN POINTS A AND C
¾" Bars @ 12" c
20'0"
26'0"
SECTION OF ARCH SHOWING SIDEWALL CONSTRUCTION BETWEEN POINTS A AND B

Cross Section of Two Spans of Reinforced-Concrete Arch Bridge on Southern Ry.

The bridge consists of four 5-center arches of 70 ft. span and 20 ft. rise from springing line to intrados. The radii of the arches are 12 ft. 3 in., 29 ft. and 56 ft., respectively. The footings of the piers are 34 ft. long, and 11 ft. wide. These footings rest on bed rock and are from 12 to 16 ft. deep from (according to the depth of the foundation) base to the line of the neat work. The piers have semi-circular faces, both up and down stream, slightly battering all around from beginning of neat work to bottom line of coping. Each pier is capped by a coping 20 in. deep and with 9-in. overhang. The piers at the springing line of the arches are finished 8.5 ft. wide and the line of the intrados of each adjacent arch, begins 15 in. from the edge of coping.

The arches at their crowns are 3 ft. 4 in. thick, with parapet or side walls 2 ft. 8 in. high. The base of rail of the new work is 46.25 ft. above the top of the footings, and 9 ft. above the track of the old line.

The entire structure above the springing line, as also in the piers, is reinforced with Johnson corrugated bars, made by the St. Louis Expanding Metal Fireproofing Co. The details of the reinforcement are shown in one of the accompanying illustrations. Beginning with the top of the coping on the piers, near the intrados, the arches are reinforced, longitudinally, with ¾-in. bars, 30 ft. long and placed 12 in. on centers, with a depth of cover of 4 in. Thence, lapping 6 ft. and placed 5 in. on centers, the reinforcement continues with 1¼-in. bars to the center of the arch, where the lap is 7 ft. Transversely, these bars are intersected by ½-in. bars, placed 3 ft. on centers. The extrados differ from the intrados in this, that in the extrados 1¼-in. bars are used throughout the entire length of the arch, placed 12 in. on centers. Expansion joints were placed 15 ft. from the center line of the pier in the direction of the crown of the arch. Between these expansion joints, along the axis of the arch, the transverse bars were spaced 2 ft. on centers. The longitudinal bars, on the extrados, are 20 and 30 ft. in length, lapping 7 ft. Three 6-in. drain pipes were run diagonally from the center line of each pier to the intrados of the arch, just inside the haunch. In the side walls ½ and ¾-in. bars, bent to conform to the shape of the same were placed.

The proportion of sand, crushed granite and cement used was as follows: In the piers and abutments below the springing line, 1:3:6; in the haunches, 1:2½:5; while in the arch proper, between expansion joints, 1:2:4 was the proportion. Stone not larger than 2 in. was required. The sand was obtained from a creek about a mile away, and hauled in wagons. The granite, quarried about 1¼ miles from the work, on the Southern Ry., crushed at the quarry in an Austin gyratory crusher, loaded direct from the elevator of the crusher into cars, and thence transferred to the work. The cement, made by the Southern States Portland Cement Co., at Rockmart, Ga., was shipped in cars to Austell, where it was tested, under the direction of the Southern Ry. for fineness and tensile strength.

The footings of both abutments and piers rest on bed rock and in every case the excavation was carried down until this foundation became sufficiently solid and sound, to meet the approval of the engineer. This section of Georgia is underlaid by granite, which in a great many instances, crops out on the surface of the ground and covers very large areas. The stratum of rock, first encountered in the construction of

Sweetwater bridge, although granite, was very rotten, and had to be taken out down to hard rock.

On the west side of the stream there is a wide flat crossed by the present line on an embankment to within 90 ft. of the stream, where a trestle carries the track to the bridge. On the east side, the ground rises more rapidly. In consequence of this, the west abutment and one of the piers came in the alluvial deposit. After going through 8 or 10 ft. of loam and clay, sand and gravel were encountered, until the rock was reached, thus making the depth of excavation, below ground surface, about an average of 18 ft.

Owing to the great tendency of the water to seep through this porous medium, thus rendering the mass so soluble as to cause it to move on itself freely, it was necessary to brace the frame work of the cofferdams very securely and sheet piling 2 in. thick was provided. The frame work or skeleton for the cofferdams, consisted of four 8x8-in. timbers, framed in the form of a rectangle, and laid within the excavated area. These were augmented by others, running longitudinally and transversely, about 6 to 8 ft. apart, to act as braces. Then at the junction of these timbers pieces of the same size and about 3 to 4 ft. long were placed vertically and toenailed to the frame work below. Upon the top of these was placed another framed set similar to the first. Around this framework the sheet piling was driven. As the excavation proceeded the frame work had to be driven lower and another horizontal section added. This was accomplished by means of a heavy piece of tough green wood, iron shod, and suspended endwise from the boom of the derrick. It was raised by the hoisting engine and then permitted to drop 5 or 6 ft. after the manner of the hammer of a pile-driver, being guided by tag lines in the hands of three or four men. In the channel pier much difficulty was experienced in getting the foundation. The current was quite swift, and it was not so easy to keep the material dumped around the cofferdam from washing away. Then, too, a July freshet got in its work, and played havoc with the work that had been done. A 6-in. centrifugal pump kept down the water until the footings were all laid. There was no prescribed plan or routine for the conduct of the work, local conditions forbade that, but when the preparations were all completed, before actually beginning the work of laying concrete, the pier in the channel was begun first, the object being to get that one out of the way of high water as soon as possible. The work was then carried on to completion just as circumstances and conditions dictated.

Construction.—The main difficulty attending the construction of the bridge was the handling of the materials, or more properly speaking, the transportation of the materials. The existing conditions were such as to preclude any chance of a long spur track at the work, which would have been of incalculable value, both for unloading and storage. Hence the best that could be done, was a track which only gave 175 ft. between rear end and the clear post. It will be seen that approaching the bridge from the west side, the railway ran on an embankment about 25 ft. high. It was necessary to put the plant on this side, so a spur track was built on a trestle, which abutted against the mixing plant. At the west end of this was erected the cement storage house so that the cement could be unloaded, by means of a chute, into the house. The slope of the embankment was smoothed off and covered with 1-in. boards which followed the curve of the embankment until they reached the toe, where they abutted against a bulkhead 4 ft. high. Thus a large storage bin was formed by stone, sand and coal. This can be seen very plainly in one of the views.

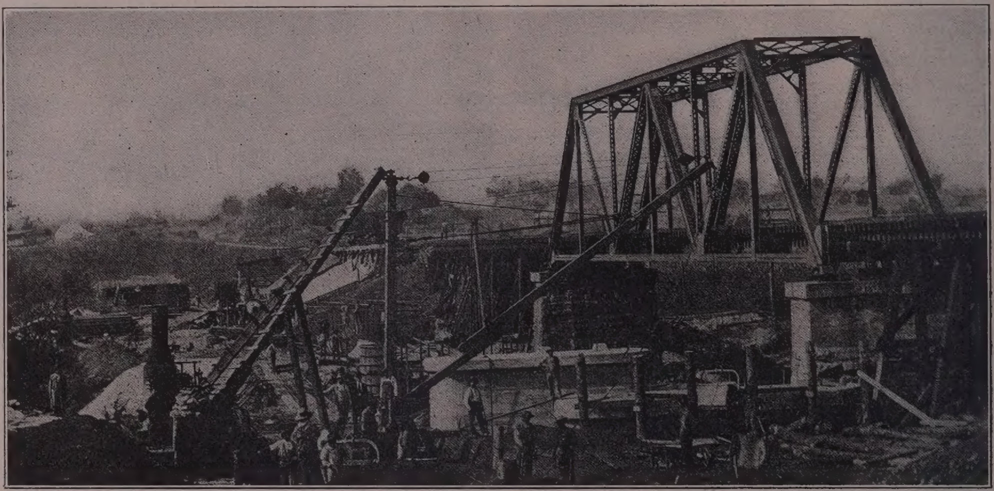
The cement house and bins were so arranged that a platform running from the former along the whole length of the latter terminated at the mixing plant where a ¾ yard Smith mixer was placed. This was located in such a way as to permit a barrow of stone or sand to be wheeled from the bin to the mixer, dumped in, and then the empties wheeled back without blocking the way or losing any time. Thus a continuous run of materials for loading the mixer was maintained.

A 300-gal. tank, placed near the mixer platform, was kept filled with water from the creek by a small Worthington double-cylinder pump, steam being furnished to the latter by the boiler which supplied the mixer engine. This tank had a pipe leading from it to the mixer which was supplied with a valve for regulating the flow of water.

The mixer was placed on a timber platform about 5 ft. above the ground, its discharge end facing east. Beginning immediately under it, and running across the stream to the extreme end of the east abutment, was a service track consisting of 3 rails having, of course, 2 gauges; that of the two rails adjacent to the bridge was 4 ft., while the second distance between the extreme outside rails, was 25 ft.

On the narrower-gauge track the small cars carrying the concrete bucket were operated, while on the broad gauge a traveling derrick was moved. This service track was built before any excavation was made in order that the excavated material might be removed by means of the buckets, which were afterward used to put the concrete in place. The traveling derrick, which was designed and built by the man in charge of the work, and which was found to be of great advantage during the construction of the bridge, consisted of a triangular framework of 8x10-in. timbers, with two pieces of similar size, running from the center of the base of the triangle to the apex of the same. Under this and attached to the framework by bolts, were 5 double-flange, 16-in. wheels, which carried the traveler on the service track. Two of these wheels were placed under the derrick end of the triangle and three under the base of the triangle, which carried a Flory double-drum hoisting engine. The mast of the derrick was 25 ft. high and was held in place by two stout stiff-legs, terminating at the masts in two very strong goose necks, while their feet were held to the traveler by straps and bolts. The tendency to tilt, when the weight was on the boom, was counteracted by boxes built around the feet of the stiff-legs and filled with stones. The stiff-legs were further stiffened by the introduction of two inclined struts, which were attached to their under side by straps and also to the framework below in like manner. The boom of the derrick shows a splice in one of the accompanying views. This was made on the score of economy. It was not necessary to use such a long boom while excavating, hence a short one was used, and then lengthened by introducing the second piece. The conditions were such as to compel the erection of the service track at an elevation too low to reach the far side of the work with the boom as operated. This was done by placing a ½-yd. side dump cradle car on a movable transverse track. The concrete was raised from the service car in the buckets, and dumped into the cradle car, which was pushed over to the far side and dumped where needed. This car and track are very plainly shown in the illustration.

The great advantage of this moving derrick will be seen at a glance; it could be moved to any part of the work in a few minutes and was at once ready for business. The manner of moving was simplicity itself; a rope was attached to the machine and passed through a pulley on a dead man, which was permanently fixed at each end of the service track. The rope was then passed round one of the spools on the hoister and the work was easily and quickly done.



Arrangement of Contractor's Plant.

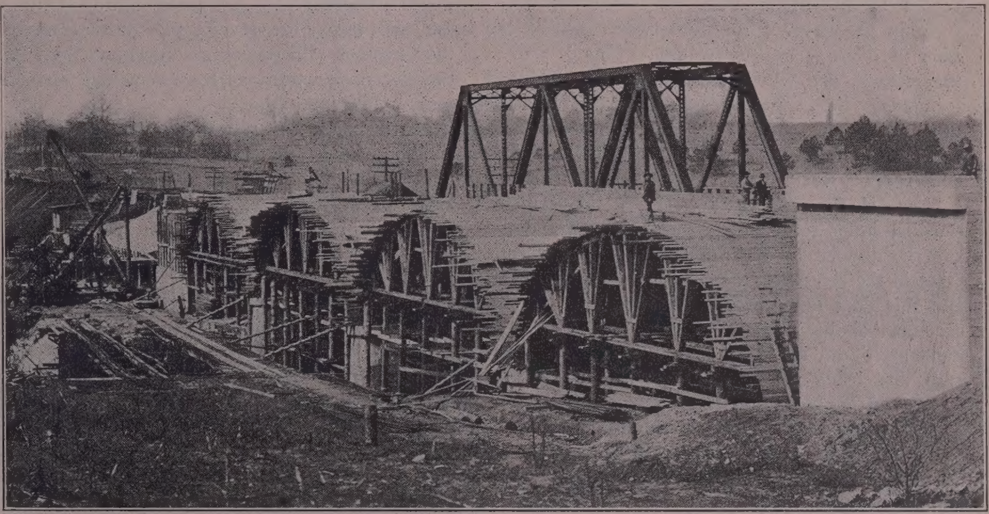
Since one of the most important problems that confront the contractor on the commencement of a large piece of concrete work is the method to be adopted for handling the concrete, it might not be out of place here to note some of the advantages of the method employed in the Sweetwater bridge, and make some comparisons. If the location of the work to be done is of such a character as to admit of its being readily and economically built, a service track, such as the one built in this case, would be the most efficient way of handling the work. Of course this presupposes no conditions which would make such an arrangement out of place or impossible. It is obvious to any one that a device that meets the exigencies of the case as completely and fully as this one must be worth considering. Here, for example, is a moving car carrying derrick and hoister, from point to point, as needed. The time lost in taking down, moving and re-erecting a guy derrick is saved and in addition to this it might not always be feasible or practicable to erect the derrick precisely where it is needed. So all things taken into consideration, the method here introduced and successfully used is entitled to a place, and a prominent place, in the economy of concrete bridge erection.

Again, the simplicity and cheapness of this arrangement are much in its favor. The ground on either side of the stream was simply smoothed off, pine poles cut to about 6 ft. in length and hewed on two opposite sides were laid down for ties. These ties were placed as far apart on centers as was permissible. In the stream, under the 4-ft. gauge, was erected a simple trestle of unbarked pine poles, with ends of batter and plumb posts, resting on the creek bottom and braced with longitudinal and sway braces. Down stream and 20 ft. from this was placed another line of posts connected with the former by braces. On the caps of these bents were placed single longitudinal stringers. Cross ties were placed on these and to them three 18-lb. rails were spiked. These rails proved to be too light and it is believed that a 40-lb. rail would have been better.

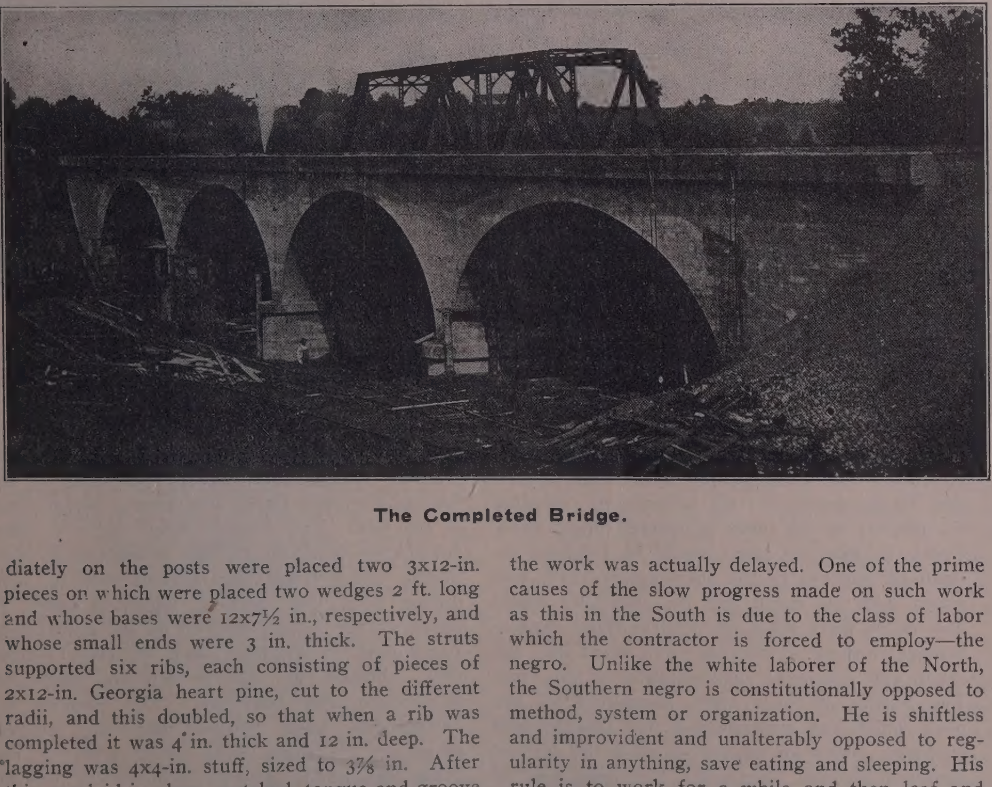
The cost of this plan was very little, compared with the cost of the whole. The five double-flange wheels, purchased from the American Hoist & Derrick Co., were the costliest part of the traveling derrick, being $30 apiece. Four carpenters can make a derrick, complete, in three to four days. The service track complete, 350 ft., with traveler, cost about $600 to $800. In other localities and under other conditions these prices might be decidedly modified. In the case of the Sweetwater work the proximity of the operated track forbade the use of guys entirely, hence a stiff-leg derrick was a necessity.

A guyed derrick could have been put there, but the mast would have to be very high in order to give sufficient clearance of guys, above the track, so this expedient, which, happily, proved a good one, was used. During a freshet in early March the water rose 5 to 6 ft. over the trestle. Only one bent was displaced, while all the falsework under one of the arches of the concrete structure was washed entirely away. The traveler was submerged until only the stack of the hoister boiler was visible.

Falsework and Centering.—The falsework for each arch consisted of seven transverse bents of round timber, six pieces to the bent. These rested on sub-sills the full length of the bent, and to which the posts were toe-nailed. On these posts rested, as plates, two 3x12-in. timbers, which formed the base on which rested the struts supporting the ribs. Transversely and resting immediately on the posts were placed two 3x12-in. pieces on which were placed two wedges 2 ft. long and whose bases were 12x7½ in., respectively, and whose small ends were 3 in. thick. The struts supported six ribs, each consisting of pieces of 2x12-in. Georgia heart pine, cut to the different radii, and this doubled, so that when a rib was completed it was 4 in. thick and 12 in. deep. The lagging was 4x4-in. stuff, sized to 3⅞ in. After this was laid in place, matched, tongue and groove dressed flooring was laid on it, forming a close, smooth surface.



Falsework and Centering in Place.



The Completed Bridge.

To show the staying power of the concrete and reinforcing combined, on March 17, with only the haunches of the arches built up, there was a freshet in the stream, which swept away all support, under the first arch, and left the 3x12-in. plates suspended. It remained so several days, until the water subsided so as to allow the workmen to get in to repair the damage. There was no appreciable deflection of the timbers.

The posts had only to be replaced, new wedges introduced and keyed up snug, when the whole presented its normal condition, with no damage, or abnormal strain on the timbers remaining.

Time.—The work was begun June 1, 1905, and was completed in one year. To the majority of readers and especially those experienced in this kind of work, this must seem an excessively long time, in which to do such a piece of work. This is undoubtedly true, and had this whole time been spent on actual construction there would have been no excuse for such waste of time. Such, however, was not the case. There were so many causes at work that militated against the progress of the work, that at least one-fourth of this time the work was actually delayed. One of the prime causes of the slow progress made on such work as this in the South is due to the class of labor which the contractor is forced to employ—the negro. Unlike the white laborer of the North, the Southern negro is constitutionally opposed to method, system or organization. He is shiftless and improvident and unalterably opposed to regularity in anything, save eating and sleeping. His rule is to work for a while and then loaf and spend his money. Again, he does not take the slightest interest in the work he is doing any further than he is forced to do, either to hold his job or escape the ire of the "boss." Then, too, he is indolent by nature, and his movements are correspondingly slow; he will not be hurried. It will, therefore, be clearly seen that to effect any sort of organization, working systematically and rapidly, with such labor, would be a grotesque farce. The superintendent is, therefore, forced to do his work in a very hap-hazard, desultory manner, causing the loss of valuable time. Although, in this particular case, while the above state of things existed to a degree, there were other causes for delays, the discussion of which does not properly belong to an article of this character, so it may be said that under favorable conditions, thorough organization, barring accidents, a piece of work of this character should be completed in six months. But the kaleidoscopic shifting of "hands" as will ever obtain when the negro is the factor, precludes any chance of making time on a job.

Removing the falsework.—When it came to removing the falsework the efficiency of the traveling derrick became very apparent. First, the wedges were removed, which left the falsework above the springing line suspended. The traveler was then moved to a point immediately in front of the center of an arch. A heavy rope was fastened to the line of posts supporting the rib farthest from the machine, this rope was passed two or three times over the spools of the hoister, with several men at the end to haul in the slack. It will be seen that when a pull is made on the farthest line that when this moves it comes in contact with the next one, and this, in turn with the next, and so on, like ten pins, until all are being pulled out at the bottom, and fall on the vertical posts beneath. The whole, therefore, was pulled down with one impulse. Then by attaching the rope to the lagging this was also made to collapse and fall. The machine was then moved to another arch and the process repeated. When it came to the removal of the form on the bench walls the mass was peeled off by the machine in sections the length of half the arch.

It is obvious to practical men that much time and labor can be saved by the use of such a device, two hours being all the time needed for taking down the falsework under one arch.

Cost of the Work.—This phase of the work must be approached with some degree of caution, for fear of misleading the unwary. What is meant is this: there were many contingencies incidental to this particular piece of work which added to the cost as a whole. Hence, in stating the cost per yard of the concrete or per yard of excavation, or per 1,000 ft. board measure of timber in foundation, the impression might obtain that the work was excessively high or remarkably low. For instance, it was necessary to make what might be termed by some rather elaborate preparations for the work—out of proportion, it might be said, to the magnitude of the work. Now, while this undoubtedly lessens the profit of the contractor, and from his viewpoint would be classed among the useless pieces of extravagance, the wisdom of it was clearly demonstrated in the present instance; and nowhere can it be better illustrated than by a comparison between this and an exactly similar piece of work being built at the same time, on the same road, and eight miles nearer the city of Atlanta. This bridge was commenced one month before the one at Sweetwater and completed one month after. All of the surroundings were far more favorable for unloading and storing material and for carrying on the work generally, yet the time of construction was two months longer. This was due, almost entirely, to poor preparation, or no preparation at all. It will be seen, therefore, that if a contractor will consent to prepare himself thoroughly for doing a heavy piece of work, although he may not make as much money in the first instance, he will eventually, by saving labor and time be more than repaid by his preparation.

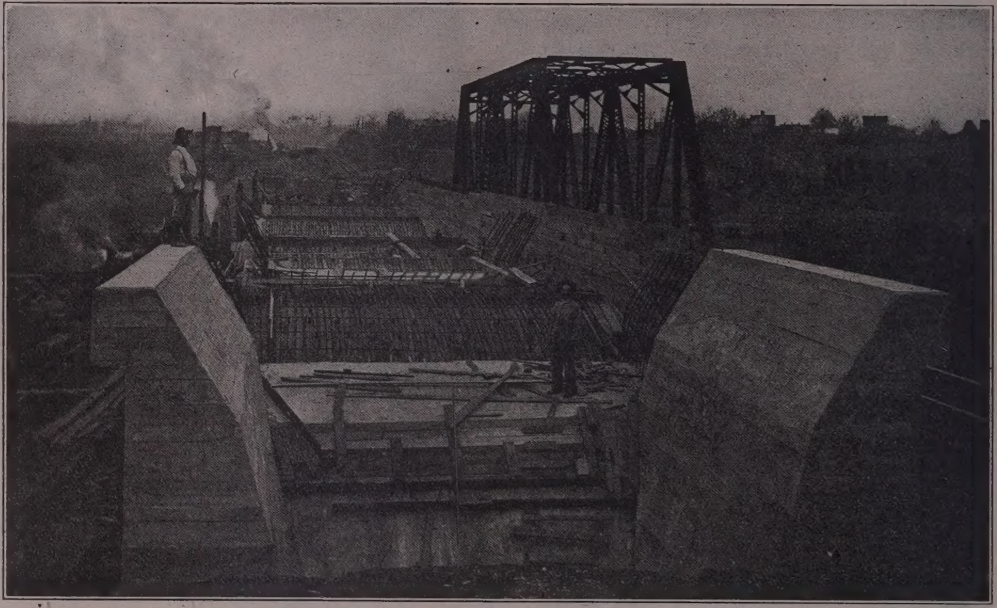
So in the case of the Sweetwater bridge the item of labor is unusually high. This is due to two causes, one which has already been alluded to, namely, the inefficiency of negro labor, and the other the large amount of work on forms and preparation that was made for doing the actual construction work.

Now, if the aggregate cost of the cement, crushed stone, sand and lumber be taken and the sum be divided by the number of yards of concrete in the structure, the cost will be $6 per yard. But this does not represent the real cost, for no account has been taken of many items of cost incident to the work, which make quite a large sum, and bring the cost per yard to $8 instead of $6. Of course a portion of this incidental expense represents construction plant, and which, although a part of the contractor's permanent assets, was necessary for this work and should be charged against it.

While the figures given below are approximations, they are sufficiently accurate, for practical purposes. There were $13,000 for labor, which sum is distributed as follows: Foundations, including excavation, pumping and constructing cofferdams, $3,000; building forms and putting up falsework and centering, $2,000; laying concrete, $4,000; hoisting and putting in place steel reinforcing, $400; removing forms, falsework, centering and dredging stream (required by mill-owner above), $1,200; putting on one coat of pitch and paper, $150; building camp, cement and tool houses, spur track, platforms, bins, trestle and service track, traveling derrick and the setting up of machinery, $2,250.

There were used in the construction 6,000 bbls. of Portland cement, 5,000 cu. yd. of crushed granite, 2,500 cu. yd. sand and about 260,000 ft., board measure, of lumber. The cement cost, on the ground, approximately $2.05 per barrel. The stone about 85 cents per yard, and the sand 80 cents. The average cost of the lumber was $17 per 1,000 ft. board measure. Now if the cost of the plant is included in the calculation the total cost of the concrete would be, as previously stated, about $8 per yard. It is in order here to state that had no contingencies arisen, such as high water and several months of delay, this cost would not have exceeded $7.50 per yard.

This bridge was designed and working plans made in the office of Mr. W. H. Wells, engineer of construction, Southern Ry., by Mr. G. H. Gilbert. It was erected under the general supervision of Mr. R. F. Ezzell, principal assistant engineer, and under the direct supervision of Mr. Jno. W. Ash, assistant engineer and chief inspector. Mr. H. C. Harrison, of Virginia, was the contractor and Mr. W. B. Savage, of Richmond, Va., as superintendent for the contractor, had charge of the field work. The work, from the beginning to completion, was given entirely into the hands of the superintendent, who planned and laid out the whole thing, and had entire charge of it, even to the employing of the labor.



Arch Reinforcement in Position. Four-Span Bridge, Southern Ry.

Electrolysis Investigations by the Metropolitan Water and Sewerage Board.

The investigations to determine the effect of electrolysis on water pipes belonging to the Metropolitan Water and Sewerage Board, of Boston, which have been conducted for a number of years by the engineering staff under Mr. F. P. Stearns, are probably more comprehensive than any made elsewhere. Last year complete voltmeter surveys of the entire district were made about the first of April, and again about the first of November, and a large number of miscellaneous investigations have been conducted in connection with experimental work. In the annual report of the chief engineer it is stated that with the exception of the change produced artificially by setting insulation joints on the two 48-in., low-service pipe lines connecting the Chestnut Hill pumping station and Spot Pond the electrical conditions have remained about the same as during 1904.

At the close of 1904 the work of setting insulation joints at several points on the pipe lines in the district covered by the Boston Elevated Railway Co. was in progress, and four of the joints had been set in the westerly 48-in. pipe line connecting Chestnut Hill pumping station and Spot Pond. In January, 1905, insulation joints were set at two points on the easterly 48-in. pipe line connecting Chestnut Hill pumping station and Spot Pond. These joints were set on the electrically positive side of the Charles and Mystic rivers, for the purpose of reversing the polarity of the pipes submerged under those rivers, so that the pipes would be negative instead of positive to the surrounding earth and water, with the result that the electricity would flow on to them from the earth without causing damage, instead of flowing from them into the earth, and causing a disintegration of the iron. The setting of these joints completed all the work which had been planned, for experimental purposes, under an agreement with the Boston Elevated Railway Company. The total cost of setting these joints at the six points on the two 48-in. pipe lines was $3,700.80.

Investigations made in 1905 show that the reversal of the electrical condition of the pipe lines under the Charles and Mystic rivers has been accomplished as anticipated, as these sections of the pipe lines are now receiving about 35 amperes instead of losing about 60 amperes, as formerly. On the portions of the pipe lines directly affected by the insulation joints there has been a substantial reduction in the amount of current leaving the pipes in wet ground and in the total amount of current leaving the pipe lines, but the currents remaining on the pipes are still of such magnitude as to cause serious injury at many points. By creating new positive districts the joints have caused a distribution of the damage over many portions of the pipe systems where it will be more difficult to locate it, and in a measure have destroyed the benefit which resulted from connecting the positive bus-bar to the railway feed wires, which was done several years ago, so as to concentrate the injury to the pipes in the district near the power station, where it could be most easily located.

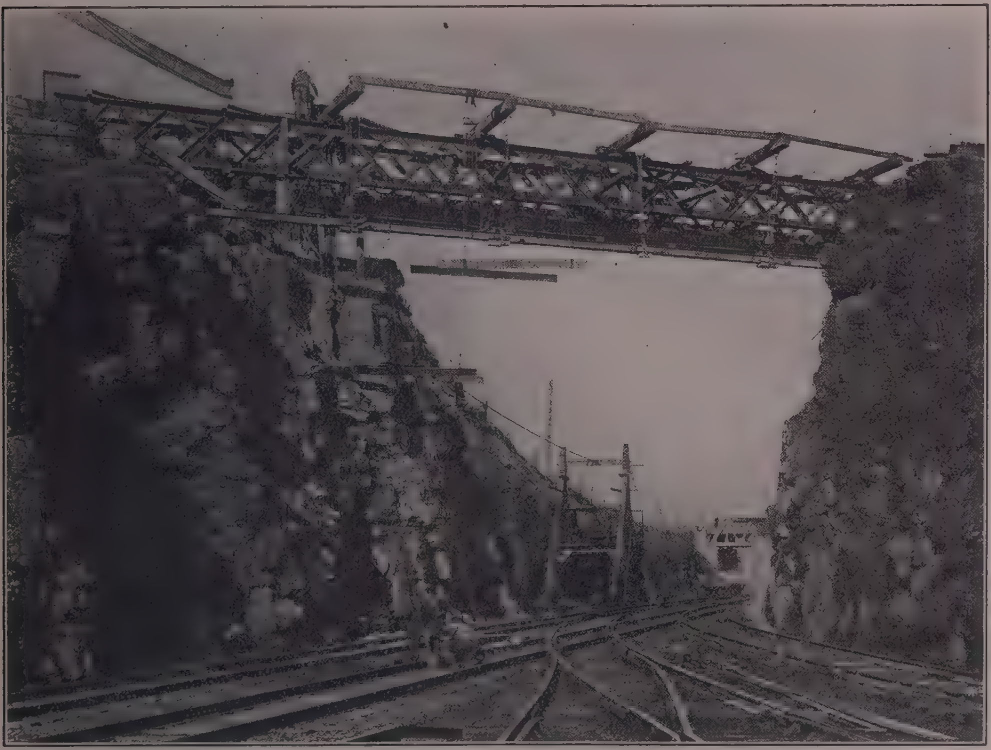
No extensive examination has been made of the pipe lines in any of these new positive districts on the positive side of the insulation joints where damage is expected from electrolysis, due to the difference of potential maintained across the joints, because it would be difficult to detect the injury done in a single year, except where the soil conditions are favorable to rapid action; but an examination of the top of the flanges at insulation joint No. 6 in Middlesex Avenue, where exposed in the chamber, revealed several distinct pits about ¼ in. deep on the positive flange; the negative flange was unaffected. This joint is covered with water during a considerable portion of the year.

Since the insulation joints have been set, it has been possible to obtain a more accurate measure of the total fall of potential on the Boston Elevated tracks and return system than in the past. This "return drop," as it is often called, was found to average as high as 20 volts during the average load periods and 40 volts during peak load periods, which is much in excess of the 7 volts allowed by the government regulations in England, and an even smaller limit allowed by the government regulation in France and Germany. The Board's investigations have shown that the amount of injury to pipes from electrolysis in any given district is directly proportional to the return drop; and that a very large reduction in the amount of electrolytic damage could be made by the railway company, by reducing the return drop so as to conform to the foreign practice.

Several cases of damage to the local water pipes from electrolysis were discovered in Boston, Chelsea, Cambridge and Hyde Park during the year, which were due to the bonding of the underground telephone cable sheaths to the tracks, to protect them from electrolysis. These facts have shown that it is very important to obtain the differences of potential between the pipes and the telephone cables. Tests were made during the year of several insulation coatings applied to short pieces of pipe, and some of them were of very high resistance; but, on account of the mechanical difficulties to be overcome in applying a perfect coating and preserving it in perfect condition in practical use, the engineers do not expect much success in attempting to prevent electrolysis by employing them.

Replacing an Overhead Highway Bridge.

About a mile north of the Harlem River, New York City, Mott Ave. crosses the tracks of the New York Central & Hudson River R. R., where the latter pass through a rock cut about 35 ft. deep. The improvements now in progress for the electrification of the Metropolitan Zone and for the completion of four tracks throughout the main line required the widening of the cut for two additional main tracks. It followed that the 60-ft. overhead highway bridge must be replaced by a longer span, and a plan was devised for doing it without any obstruction to the tracks below. The old bridge consisted of three pin-connected, five-panel deck trusses carrying a gas main and a 6-in. water pipe on the center line over the middle truss. These pipes were boxed in and formed a division line between the two roadways, outside of which there were two cantilever sidewalks. At the ends of the bridge the gas pipe and water main were depressed several feet below the surface of the street.



Method of Removing Bridge at Mott Avenue.

Operations were commenced by the delivery of two 110-ft. lattice girders from the Rondout Viaduct, which had recently been replaced by plate girders. These were brought across the old span by trucks and were unloaded there and supported on temporary timber cribbing at the ends beyond the line of the future extension of the railroad cut. They were braced together with wooden transverse frames, and the gas and water mains were suspended from them. Traffic having been diverted from the old structure, its deck was removed, leaving the three trusses and their transverse bracing clear of the 110-ft. girders above them. Five 12x12-in. timbers, 30 ft. long, were transversely set on the top flanges of the girders so as to project equally at each end. The top chords of the old trusses were connected at panel points to these cantilevers by means of light tackles, and the trusses were disconnected by men on suspended platforms, who drove out the bottom chord pins. The lower chords were thus released and removed by tackles suspended from jigger beams set on the ends of the cantilevers. Subsequently the vertical and diagonal members of the trusses were secured in the same manner and hauled up after the top chord pins had been driven out; finally the sections of the top chord were removed as shown in the accompanying illustration, thus completing the demolition of the old structure. The beams and tackles were then stripped from the 110-ft. trusses, leaving them to support the water main and carry it while the rock is blasted away on one side of the cut and the latter enlarged to its final dimensions, after which the new abutments and superstructure will be constructed. This work did not maintain street traffic over the railroad tracks, but provided for the maintenance of the water supply and afforded a simple and economical method of removing the old structure.

The work was done under the direction of Mr. W. J. Wilgus, vice-president, and Mr. G. A. Berry, engineer of company forces for the New York Central & Hudson River R. R.

A Rotary Snow Plow has been provided for the new Long Island R. R. electrical equipment. It is of steel construction, and is equipped with one motor and one trailer truck of standard types, and all of the standard motor car electrical equipment for operation in trains. A set of revolving blades with fan and housings is mounted at each end of the car, which is operated by one line shaft running through the car and fitted with two friction clutches, one for each end section. The center section carries two 50-h.-p. railway-type motors, operated by a series parallel controller of the platform type.

A Legal Definition of "Rated Capacity."

There is often a pretty wide difference of opinion concerning what is meant in this country by rated capacity. It is probably most noticed by the general public in the case of motor cars and house-heating apparatus. It is perfectly well known that a 40-h.-p. car of one builder may not have over half as much power as a 30-h.-p. car of a different make, owing to the difference in the methods of rating their products adopted by the two makers. The troubles caused by the rating systems for heating boilers is known even more widely, and for this reason attention is called to a recent decision of the Wisconsin Supreme Court on this subject. The case hinged on a sale of a boiler by the plaintiff, the United States Heater Co., to Ed. La Londe & Son, to be placed in a building belonging to the defendant, A. Jenss. The defendant gave the plaintiff the following guarantee for the payment for the boiler:

"I hereby guarantee to you payment for the No. 626 Capital steam boiler, also radiators and other heating supplies, to be placed in my building at Antigo, Wis., by Ed. La Londe & Son, of Antigo, Wis., and in accepting this security it is understood that you are in no way held responsible in connection with the installation of this system except as to the rated capacity of the boiler; payment for same to be made not later than sixty days after shipment, total amount of bills not to exceed $475."

The builders failed and the boiler makers accordingly applied to the defendant for the money due them under the above guaranty. This payment was refused on the following grounds: The plaintiff agreed to sell the builders, the La Londes, a boiler and heating apparatus of sufficient capacity to warm the house properly at all seasons of the year, and the consideration for the guaranty was this agreement. The plant was stated to be wholly inadequate, and as soon as the plaintiff ascertained this fact he refused to accept the installation as satisfying the contract conditions. When the case came up in the trial court, the court held that the defendant was liable under the guaranty, contingent upon the rated capacity being as represented, 1,000 sq. ft. of heating surface. The court further held that the term "rated capacity" in the guaranty referred to that matter and not to the efficiency of the boiler for warming the house in which it was installed. The evidence given during the trial concerning what was meant by rated capacity was summed up by Judge Marshall, of the Supreme Court, substantially as follows: All heating boilers are rated on the basis of grate and boiler surface, exposure to heat, and hard coal as fuel. The plaintiff rated the boiler in question in the regular way, on that basis, at 1,000 sq. ft. A witness, who confessed inexperience in such matters and lack of knowledge of the proper method of measuring a boiler for determining its rating, testified that the surface exposed to heat in the boiler in question was 76.81 sq. ft. In connection with that there was evidence that on such a basis the proper rating of the boiler with hard coal for fuel would be 430 ft. There was also undisputed expert evidence to the effect that the method of measuring the boiler to furnish this result was so unreliable as to furnish no proper basis whatever for determining the proper rating of the boiler. The decision of the Supreme Court on this subject reads as follows:

"The learned circuit court, it seems, decided rightly in holding that the term mentioned had no reference whatever to the subject-matter of the defense, viz., the efficiency of the boiler when set up with proper connection, to satisfactorily warm appellant's house. The evidence shows quite conclusively, as the words in themselves pretty clearly indicate, that such term refers merely to the theoretical capacity of the boiler according to the customary way of rating such articles by dealers, to the trade. We shall not take time and space to discuss the evidence in detail. It is all one way, to the effect that heating boilers, generally, are put upon the market by dealers as having each a stated capacity, the rating being based on the idea that a square foot of boiler and grate surface exposed to heat is convertible into a certain heating surface of radiators and connections, the amount varying according to the kind of fuel used, hard coal being the standard.

"So the verdict was properly directed for plaintiff, unless there was evidence to carry the question to the jury, of whether the boiler was in fact theoretically rated at 1,000 square feet of heating surface, as was supposed at the time the guaranty was made. As to that the burden was on defendant to prove the negative. He failed to produce any definite evidence in support thereof. There was evidence, as is indicated in the statement, that according to a method of measurement and computation applied and testified to, the appellant's rated capacity was too high. But since the evidence was given by confessedly non-expert witnesses, the subject was clearly within the field of expert inquiry, and there was undisputed credible expert evidence that such method was wrong, and entirely unlikely to show, with any reasonable degree of accuracy, the proper rating of the boiler; there was no proof whatever at the time the verdict was directed, supporting the claim of the appellant. On the other hand, there was considerable evidence of an affirmative character, that the boiler had a legitimate rating in harmony with that for which it was sold; not evidence based on measurement and computation, it is true, but on evidence of one familiar with boilers to the effect that the grate surface and size of the boiler indicated that the rating given to it by respondent was correct. There was no evidence upon which the jury could have found in favor of the appellant."

A Large Coaling Station has been erected at Purfleet, England, by the Steamship Owners' Coal Association which involves a reinforced concrete pier and two rapid-working hydraulic transporter cranes with grab buckets. The pier is parallel to the shore line and situated some 200 ft. distant from it, and is 34 ft. in width and 400 ft. long. The cranes are designed for lifting coal from barges and delivering either into a steamer alongside, into a barge on the river side of the steamer, into a barge on the land side of the pier, or into trucks running on rails on the pier beneath the cranes. The cranes have four legs each carried on 8-wheel trucks, the gauge of tracks being 28 ft. and the wheel base 24 ft. The trolley runway tracks are carried at a level of 32 ft. above the pier, the outboard runway having an overhang of 48 ft., while the total travel of the trolley from extreme outboard position to extreme position on the land side of pier, is 96 ft. The trolley runway is fitted with a weigh-bridge by which each grab bucket full may be weighed into and out of vessels. The lifting, lowering and traversing motions of the crane are all operated hydraulically, hydraulic pressure being supplied by a 120-h.-p. pumping plant at the shore end of the approach pier. The hoisting and trolley traverse movements are operated by large hydraulic cylinders controlled from an operator's cabin, while the crane is traversed along the pier by a three-cylinder rotary hydraulic engine. The cranes have each a nominal capacity of 50 tons of coal per hour, but have in practice exceeded 70 tons.

Reclaiming Low Land With Sand Pumped from a Foreshore.

An area of about 700 acres of land toward one end of a long narrow peninsula extending out from the southerly shore of Long Island within the limits of New York City is being raised from its present elevation of 2 to 15 ft. above mean tide to a uniform elevation of 10 ft. above that level with sand pumped in from the shore on the sea side of the peninsula. The latter is formed entirely of sea sand and is being extended very rapidly to the west toward lower New York Bay by the action of currents and waves. A number of summer resorts are located along the shore of the peninsula, while portions of it have been improved and are already quite closely built up with the dwellings of permanent residents. Much of the land that has been improved has been filled in at a cost of 30 to 40 cents per cubic yard with sand hauled in wagons from the shore. The filling that is now being carried on is done entirely by hydraulic methods at a cost not to exceed 5 cents per cubic yard.

Two electrically driven dredging outfits have been installed in temporary buildings erected on the shore in such a position that their suction pipes are submerged at all stages of the tide. The variation of the tide along this shore is about 5 ft., and as the beach is quite flat the two buildings in which the outfits are installed had to be erected on piles to keep them above any danger of damage from wave action. Each building is 24 x 33 ft. in plan, and is erected on 6 longitudinal and 7 transverse rows of piles spaced 5 ft. apart on centers in both directions. Each transverse row is capped with two 6x12-in. timbers, over which is laid a 4-in. plank floor. The housing built over this floor is erected simply as a protection to the machinery equipment installed in the building.

A 12-in. Morris centrifugal pump belt driven by a 250-h.-p., 440-volt, alternating-current Westinghouse motor, operating at 580 r.p.m., is installed in one building. In the other building the equipment is the same except that a 200-h.-p. motor was installed. Power is purchased from a local lighting company and is transmitted to the building at 2,200 volts and then stepped down to 440 volts. Both of the pumps were specially designed for the work. The suction of the pump driven by the 250-h.-p. motor has a total length of 88 ft., and extends out into the water on the sea side of the building. A stiff-leg derrick is erected on that side of the building on three pile pedestals, one just outside of each corner of the building and the third 25 ft. from it. The mast of the derrick is erected over this outer pedestal. A swivel elbow is placed in the suction directly under the derrick mast. A 12-ft. length of rubber suction connects this elbow with the remaining 60 ft. of the suction pipe, which 60 ft. is suspended at two points by steel cables rove in blocks carried by the 45-ft. boom of the derrick. A single-drum reverse swinging gear hoisting engine in the building, also driven by the motor, is used in operating the derrick. The outer 60 ft. of the suction may thus be revolved through an arc of 250 deg., and may be lowered until the suction limit of the pump is reached, or raised above high-water level.

The extreme vacuum under which the pump operates approaches the maximum amount obtainable under practicable conditions, or about 28 in. of mercury. The head against which the pump operates varies from 15 to 30 lb., depending on the length of the discharge main, and is entirely due to friction in the latter. A vacuum pump is provided in the building to prime the main pump. A small hydraulic pump was installed to provide sea water to the bearings of the main pump, but since the suction for this pump had to be extended for some distance out from the shore before drifting sand could be avoided, fresh water from a local water works system is supplied to the pump bearings.

The arrangement of the equipment in the other building, which is about 1,000 ft. away along the shore and was built some time after the first one was erected, has been changed somewhat. Inasmuch that no difficulty was experienced from the waves in operating the first installation, the pump in the second building was set 5 ft. lower by dropping a portion of the building floor. The suction of the pump was also made straight and its outer end simply arranged to be lowered and raised by the derrick without any provision for rotating it. In this manner the suction lift was sufficiently reduced to have a very material effect on the capacity of the pump. The pumps are operated during a 10-hr. day shift only, and it has been found that the sand is moved along the shore to such an extent by the waves that an amply supply of sand is available at all times during the 10-hr. period, while the hole that has been excavated during the day is generally filled up during the night.

The discharge pipes leading from the pumps vary from 500 to 3,000 ft. in length, depending on the location of the area on which the sand is being deposited. Twelve-inch spirally riveted steel pipe made by the American Spiral Pipe Co. is employed. A special form of joint built by that company for work of this nature is used in making the connections between the sections of pipe and has demonstrated its adaptability to the requirements. Although not a ball and socket joint it is so made that angles of as much as 15 deg. may be turned at a single joint without affecting the water tightness of the main. The pipe sections are fastened together at the joints, which have flat flange faces, by bolts. The discharge mains are carried on cross pieces nailed to a post on each side of the main, the points of support being about 12.5 ft. apart.

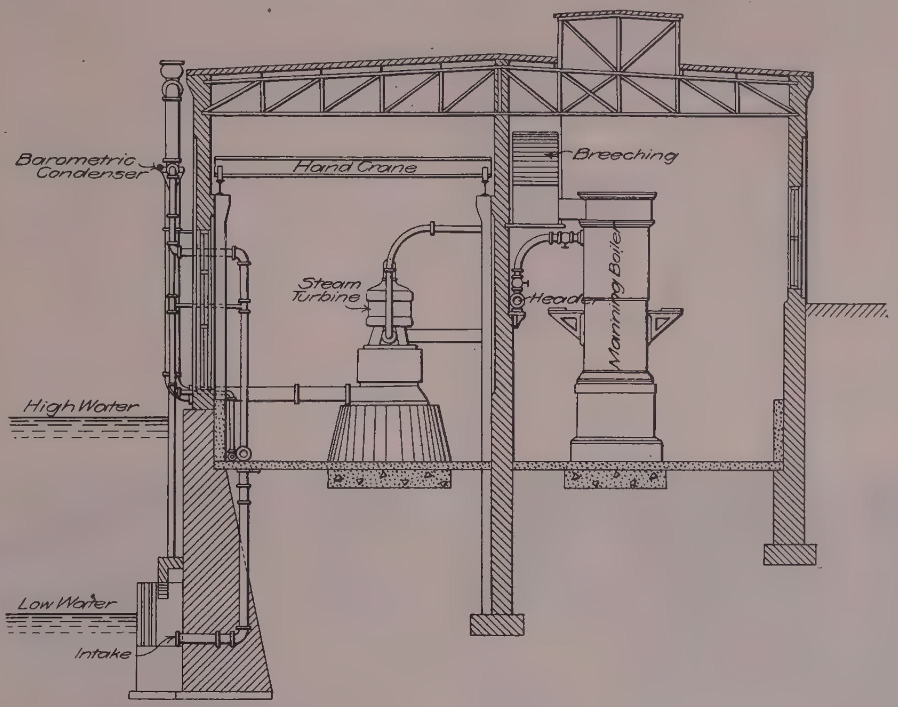
The two dredging outfits were built and are operated under the direction of Mr. Ernest C. Moore, consulting engineer, of New York City. They are the outcome of a similar installation built by Mr. Moore some time ago about 4 miles east of them on the same shore at Edgemere. In the Edgemere installation, however, the derrick was operated by hand and a number of other features were different from those of the stations just described.

A Specially Designed Pressure Blower has recently been built for the Chicago, Burlington & Quincy Ry. which is to supply draft for gas furnaces in the forge shop at the Aurora, Ill., repair shops. It was required by the railway company that the blower be capable of supplying 7,200 cu. ft. of air per minute at a pressure of 10 oz. per square inch, and in order that it might be driven by direct connection to an electric motor of standard make, it was stipulated that the blower be designed to run at 830 r.p.m. As it is usual in blowers built to produce a pressure of 10 oz., to operate at comparatively high speeds, usually 1,200 to 1,400 r.p.m., a special design was here required to secure the results desired at this low speed. This was accomplished by building the blower with a blast wheel 73½ in. in diameter and 3 in. wide at the periphery, the pressure being secured by high-peripheral speed, of the wheel rather than by a higher number of revolutions per minute. The blower was built with a three-quarter housing, 110 in. in diameter over all, which has a bottom horizontal discharge outlet in order to raise the motor up to the height of the axis of the blast wheel, nearly 5 ft. above the floor. The blower is driven by a 60-h.-p., 220-volt, direct-current motor which is connected to the blast wheel through a flexible coupling.

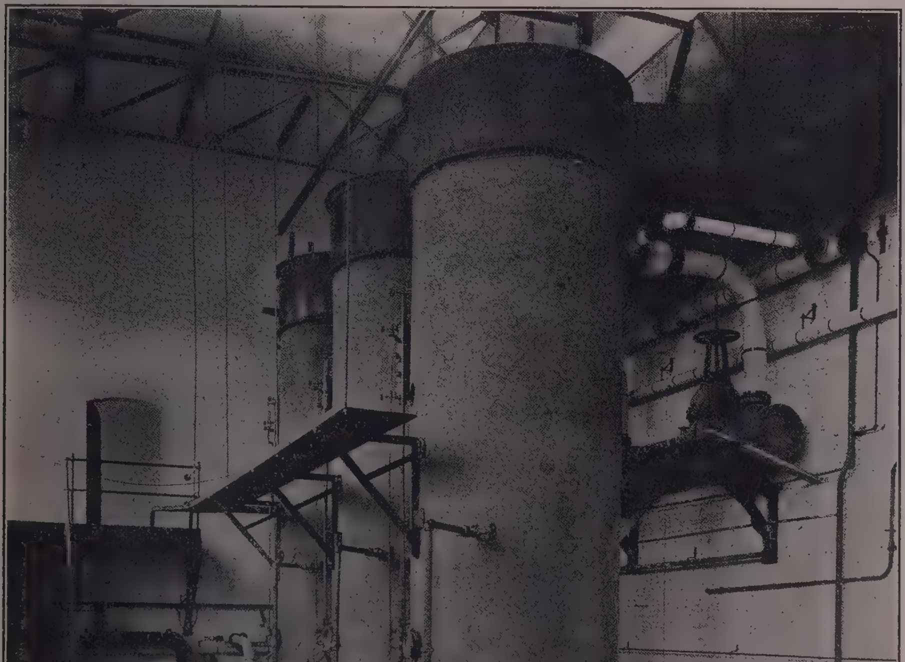
The New Hydro-Electric Station of the Holyoke Water Power Co.—II.

Steam Auxiliary Equipment.—The total capacity of the steam generating equipment that has been provided for in the new hydro-electric plant of the Holyoke Water Power Co., Holyoke, Mass., reference to which was made in the preceding issue of this journal, is three 500-kw. steam turbine units and seven 200-h.-p. boilers, although owing to the present excess of water power available over the maximum possible demands of the power distribution service, only one turbine unit and three of the boilers have been installed and these only for the purpose of providing against any emergency which might arise from disabled wheel equipment or possible abnormally low water conditions in the river.

While it is expected that in order to develop the maximum projected capacity of the plant, 3,000 h.-p., the steam plant will be required to operate only during a very small percentage of the time, amounting to only about 2 per cent of the time in wet summer seasons, and about 30 per cent. of the time in an abnormally dry season, it is to be noted that the plant is not in any sense a temporary installation nor have any of its details been slighted. Owing to the fact of the extended periods of idleness which this equipment will experience, every precaution has been taken to render all of the apparatus serviceable when suddenly called on in emergency. A factor that favored the selection of the steam turbine for the prime mover in place of a reciprocating engine was the quickness with which it was possible to start up a steam turbine in emergency, while at the same time the lesser amount of attention required in shutting down for extended periods of idleness as compared with the reciprocating engine, was of no little importance.



Cross Section of the Power House showing Steam Auxiliary Equipment.

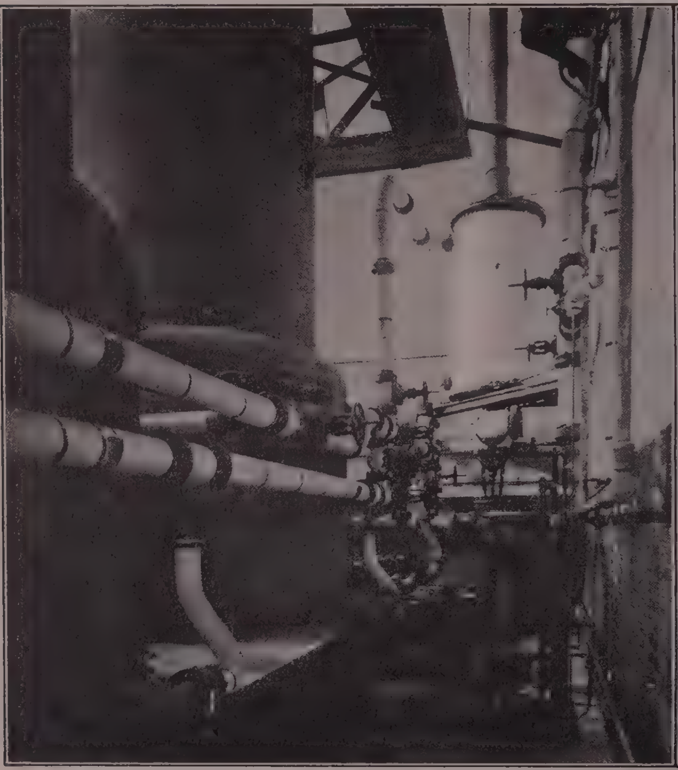


View of Boiler Equipment and Steam Piping.

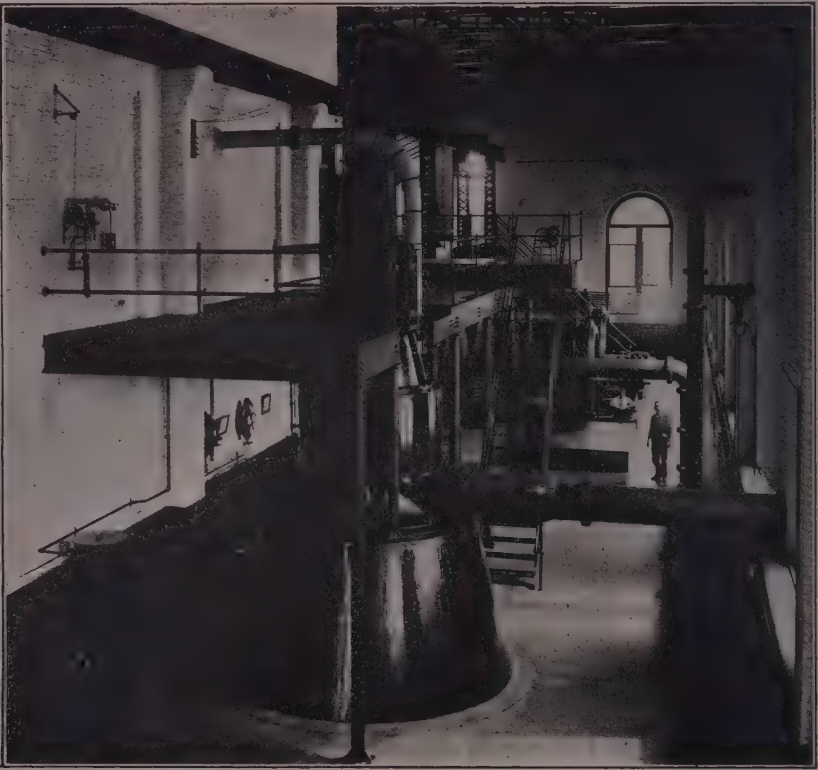
The boiler equipment consists of three Manning type vertical boilers, each of 200-h.-p. capacity, which were built by the Holyoke Steam Boiler Works. The boilers are 26 ft. in height and 6 ft. 3 in. in diameter through the tube section and 7½ ft. in diameter over the enlarged furnace portion at the base. The tubes used are 16 ft. in length and provide, with the furnace heating surface, a total heating surface of 2,000 sq. ft. per boiler. Runways are provided along both front and rear of the boilers at a point 15 ft. above the floor level for access to gauges, fittings and pipe connections. At the top of the boilers are 36-in. smoke boxes which deliver through 24x60-in. smoke connections to a 4x4½-ft. breeching at the rear. This breeching continues toward the rear of the building where, enlarged to 9 ft. in height, it is connected with the stack outside. The stack, which is 175 ft. high and has a flue 7 ft. in diameter, was built of radial brick by the Alphons Custodis Chimney Construction Co.

The coal supply for the plant is provided in a large open storage pit at the rear of the building between the stack and the roadway adjoining the railroad track on the boiler room side, which has a capacity of 2,500 tons. The pit is built at the boiler room floor level and has heavy concrete retaining walls surrounding it which are built up to a height of the ground level at the rear, thus permitting coal to be dumped directly to the storage pit from cars on the adjoining tracks. Coal is handled from the pit to the boiler room by narrow-gauge charging cars which run on floor plate tracks laid in the floor, so that coal may be shoveled directly from the cars to the boiler furnaces. A good grade of bituminous coal, costing $4 to $4.10 per ton delivered, is used, plain hand-fired rocking grates being provided in the boiler furnaces.

The boiler feeding system is in duplicate throughout, and four distinct sources of water supply are available to provide against interruption of service. With the turbines operating condensing, the feed supply will ordinarily be taken from the hot well of the condenser, but both condensing and make-up water will be taken from the 16-in. line from the canal which will deliver it to the feed pumps with a considerable head. Suction connections are also provided to the river below which permit of its being drawn from that source also if necessary, while a fourth source of supply is from the city water system which has a gravity supply delivering in this portion of the city at a pressure of about 100 lb. Two feed pumps are installed in duplicate, each of which is capable of supplying the entire equipment of seven boilers for which provision is made. These pumps, which were furnished by the Deane Steam Pump Co., of Holyoke, and have a maximum capacity of delivering 30,000 lb. of water per hour, deliver through 3-in. connections to a closed feed-water heater, supplied by the National Heater Co., New Haven, Conn. This heater is by-passed for direct delivery to the feed lines if desired. The steam supply for the heater is taken ordinarily from the exhausts of the feed pumps and other steam using auxiliaries in the plant, but has a live steam makeup connection for additional heating with high pressure steam if desired. Two feed lines of 3-in. extra heavy brass piping are provided, one of which has branches connecting into the boilers on the front sides at points 5 ft. above the crown sheets, while the other delivers into the boiler blow-off connections at the rear of the mud rings. The former boiler feed branches are 2-in. branches of extra heavy brass and are each fitted with three gate valves thus permitting the check valve, piping and intermediate graduating valve to be entirely taken down if desired. The feed branches connected to the blow-off tees are of 1½-in. extra heavy brass pipe and are fitted each with a stop and check valve only. The blow-off connections from the boilers are all 2½-in. extra heavy brass connections with blow-off cock and gate valve which connect into a 4-in. extra heavy cast-iron blowoff pipe laid below the floor surface and leading to an outlet at the rear of the building.



View of Feed Piping Connections at Rear of Boilers.



The Steam Turbine Generating Set in the Wheel Room.

The steam piping system is similarly installed in duplicate, comprising a main header from which the turbines are to be supplied and an auxiliary header which supplies the exciter engine, the pumps and auxiliaries, and which may also be utilized in supplying the turbine if a section of the main header is temporarily out of service. The main header is a 14-in. extra-heavy steel pipe with 6-in. branches through long radius bends to the boiler steam nozzles which branches are fitted with a gate valve at the header and a non-return stop valve at the boiler nozzle. The auxiliary main is of 5-in. pipe and is supplied by 2-in. boiler branches which connect through two gate valves to side outlets from the boiler nozzles. The main header has at present only a single delivery connection, consisting of a 7-in. branch to the throttle of the steam turbine which is carried through the wall through a 180-deg. long radius bend. The auxiliary main has a 3-in. branch supplying the steam turbine exciter unit, another 3-in. branch with 2-in. connections to each of the boiler feed pumps and further branches to the step bearing pumps and oil pumps. The exhaust system has been rendered simple by the use of an independent condenser for the generating unit to which a short direct connection is made from the turbine across to the outer wall of the turbine room. The steam auxiliaries exhaust into the feed-water heater, the exciter unit through an 8-in. exhaust pipe and the pumps through a 4-in. connection, and from the top of the feed water heater, which is located in an elevated position in the rear corner of the boiler room, an atmospheric vent connection is made to an exhaust head above the roof. The high pressure steam lines are all dripped to a receiver pump which discharges into the hot well while the dirty drips from the auxiliary exhaust connections are discharged into the river, for which purpose a drip discharge pump is installed to handle this discharge in case of extreme high water in the river adjoining.

The steam turbine generating unit is a 500-kw. Curtis turbine supplied by the General Electric Co., with mechanically operated governing mechanism. The turbine operates at 900 r.p.m., and is designed for an overload capacity of 25 per cent. continuously. It will operate with saturated steam, no superheaters having been installed in the boilers. It exhausts through a 16-in. pipe connection extending directly across through the outer wall of the power house, where it is carried up to a Bulkeley barometric condenser of 800-h.-p. capacity. At the top of the exhaust riser connection is an atmospheric relief valve, permitting free exhaust to the atmosphere in case of failure of the condenser equipment. The injection water for the condensers is taken ordinarily from the canal and drawn by vacuum into the jets, a lift of from 10 to 12 ft., but connections are also provided permitting water to be handled from an intake from the river below and also for the use of city water in starting the condenser in operation. The discharge of the condenser is delivered through a 6-in. pipe to the hot well in the boiler room but also has a connection by which it can be wasted to the river.

The turbine generator is designed, like those driven by the water wheels, to deliver three-phase alternating current at 2,300 volts and a frequency of 60 cycles, provisions being made for operating all generators in parallel. It is supplied with excitation current by the duplicate exciter equipment, consisting of the 50-kw. water-wheel-driven exciter and a 75-kw. Curtis steam turbine generating set, of the new horizontal type, which is located in the engine room. The steam turbo-generator is of the usual revolving field construction designed for high-speed operation.

The cables from the generators are run in iron pipe conduits embedded in the floor to the columns supporting the switchboard gallery, and up along these and under the floor of the gallery back of the switchboard where they connect with oil switches. Two conduits are provided, one for the generator cables and the other for the field coil wires, the latter carrying in addition the wire controlling the small motor on the water-wheel governor. From the oil switches the 2,300-volt current passes to the bus-bars, and thence to the feeder panel switch. At present there are three outgoing feeder lines, one of which is not in use. One line is connected with the municipal lighting plant switchboard so as to furnish the city with power when called on to do so, on certain nights when the stores in Holyoke remain open for shopping and the municipal lighting plant is unable to carry the load. This arrangement also permits the municipal plant to shut down for repairs, the entire load being carried by the Holyoke Water Power Co.'s plant. The other feeder extends along the highways to Perkins' Paper Mill in South Hadley which is run by induction motors; the length of this line is over four miles, and the voltage is stepped up to 6,600 volts by three oil-cooled transformers of 75-kw. capacity each, before current is transmitted over it.

The switchboard is made up of 12 panels, consisting of two exciters, one regulating, six generator, and three feeder panels. The panels controlling the water-wheel generators are provided with push-button switches for controlling the water-wheel governors, through three-wire systems feeding the small motors attached to the governor mechanism. This motor serves to shorten or lengthen the valve stem on the governor control, according to the will of the operator.

This plant was designed throughout by the engineering department of the Holyoke Water Power Co. Mr. Chas. E. Gross is president of the company, and Mr. B. F. Simmons, superintendent in charge of the plant.

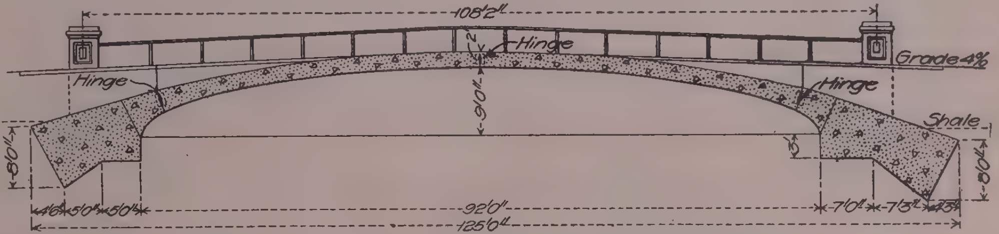
A Three-Hinged Concrete Arch Bridge.

A three-hinged semi-elliptical concrete arch bridge containing no steel reinforcement except a few bars used to tie together the face of the arch and spandrel walls built up on it, has recently been completed in Brookside Park, Cleveland, Ohio. The general design showing the location of the hinges and a view of the completed structure are given in the accompanying illustrations. The shape of the arch is a semi-ellipse whose major axis is 92 ft., and minor axis, 9 ft. These dimensions, however, can scarcely be considered as those of the true arch, as the arch proper terminates at a hinge at each of the abutments. The true rise is therefore really the vertical distance between a horizontal line drawn through the center of the abutment hinges and one through the center of the third hinge at the crown, or 5 ft. 2½ in. The true span is likewise the distance from center to center of the abutment hinges, which is 86 ft. 4½ in., making the ratio between the rise to the span about 1 to 16½, so that the arch is at least among the flattest semi-elliptical arches that have been constructed.

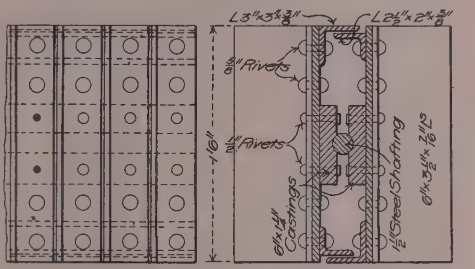
The position of the hinges was so chosen that no tension is produced in any portion of the arch, even with an unbalanced live load. For that reason it was considered unnecessary to incur the extra expense of steel reinforcement, as Mr. A. W. Zesiger, assistant engineer of parks of Cleveland, who designed the bridge and who has supplied the information from which this description was prepared, believes it is poor design to place steel in concrete where the latter is in compression, since a maximum compression stress of 500 lb. per square inch is allowed on the concrete, while the steel takes about 5,500 lb.

Fearing that the shrinkage which occurs in concrete when it is permitted to set in air, together with a fall in temperature and the axial stress were sufficient to crack the arch, even though the abutments (which were built into and rest on solid shale) were perfectly rigid, it was considered the safest and cheapest construction to put three hinges in the arch, thus giving it perfect freedom to adjust itself to all conditions. The hinges were built up of structural steel plates and angles, steel shafting and cast-iron bearing plates. The details of their construction are shown in one of the illustrations. The bearing plates were carefully fitted to the steel shafting so as to procure a uniform bearing on the shaft. The hinges weigh more than 10,000 lb., but are so completely imbedded in the concrete as to prevent their displacement. A joint, ½ in. wide, was made in the concrete of the arch in the plane of each hinge. The shaft and bearing plates were carefully greased before being placed in position and the hinge joints protected by a thick coating of tallow to prevent water reaching the bearing. The ½-in. joints in the concrete at the hinges were closed and calked with pure asphalt, which excludes water from the hinges and also allows a movement of the arch sections if such movement is necessary.

The concrete was made of Portland cement, siliceous lake sand, and crushed stone in the proportions of 1 : 2½ : 5. The concrete in each portion of the arch between the hinges, except a strip about 1 ft. wide along the side faces, was laid continuously until complete, to prevent the formation of any seams. The narrow strip along the faces of the arch was built continuous with the spandrel wall, each portion of this strip between the hinges being built without stopping, to prevent the appearance of seams. A 2½-in. layer of mortar, placed simultaneously with the remainder of the concrete, was used on all exposed faces. One abutment was built up to the hinges on that side of the arch in one day, and then one-half of the arch proper built the following day, and so on until completion.



Cross Section of Three-Hinged Concrete Arch Bridge.



Details of Hinge in Arch.

Three-Hinged Concrete Arch Bridge before Hand Railing was Placed.

The falsework required to carry the forms in which the arch was built had to be strong enough to support the entire weight of the arch, about 1,000,000 lb., exclusive of the hinges. When the centers were removed it was found that a deflection at the crown of the arch of 1½ in. took place, an amount considered sufficient to have cracked the concrete if the hinges had not been provided. With a shrinkage of the concrete equivalent to a compressive stress of 4,000 lb. per square inch in the steel, the shortening due to the compressive stress, assumed to be 250 lb. per square inch on the average, and to a difference of 28° Fahr., reached a total of 0.15 ft., in half the arch, an amount sufficient to have caused the crown of the arch to drop 1.45 in.

The bridge was built by the Block Bridge & Culvert Co., of Indianapolis, Ind.

The Life-History for Eight Years of the Experimental Coke Clinker Filter-Beds at Kingston-on-Thames.

A paper, somewhat abridged, read before the Royal Sanitary Institute, by Douglas Archibald.

The establishment and record of results with these beds form a somewhat unique chapter in sewage disposal, on account not merely of the exceptional character of the chemical treatment and purification in the Kingston tanks, but because at the present time the coke bed, after eight years' continuous working, with scarcely a single day's rest, and after no alteration to, or cleansing, except on one occasion, is now receiving and dealing with no fewer than eight fillings a day of the Kingston tank effluent (at the special request of the royal commission) and is giving an average purification thereon of about 61 per cent (from an average of ten daily averages), as reckoned by the analyses of albuminoid ammonia.

Experimental Coke and Clinker Filter-Beds.—The Native Guano Co., for whose system of precipitation the works were designed, were able to satisfy all the requirements of the Thames Conservancy with the unfiltered tank effluent from 1888, when they started working, up to 1896, when the conservancy demanded a stricter standard all the way up the river. The company, as soon as they knew of these requirements, at once determined to erect experimental contact beds to supplement the tanks, one of coke-breeze and the other of clinker.

I propose in this paper to give a brief account of the results from the prolonged working of these beds which may aid in showing what can be done by single filtration of a high-class chemical effluent, from which all the suspended and a large proportion of the dissolved solids have been eliminated in the tanks.

TABLE I.—DIMENSIONS OF THE COKE AND CLINKER BEDS.

	Coke-bed.	Clinker-bed.
Length	20 ft.	20 ft.
Breadth	11 ft.	11 ft.
Depth	3 ft.	3 ft.
Material—		
Bottom, 9 in...	Unbroken coke, 4 to 6 in.	Large clinker, 4 to 6 in.
Second, 9 in...	Broken coke, 1 to 2 in.	Clinker, 1 to ¼ in.
Top, 18 in....	Breeze, with dust removed, ¾ to ¼ in.	

The empty capacity would thus be 4,125 imp. gal. As will be seen later the water capacity of the coke bed was abnormally small, probably owing to some obliquity in its construction. The water capacity of the clinker bed was normal.

The filling and emptying of these beds has been based upon two hours' actual contact, and as much aeration as was possible consistent with the number of fills per twenty-four hours. This is very similar to the plan by which the Roscoe beds at Manchester were worked.

With six fills the times have been thus: Start filling, 6.00 a. m.: full, 6.15 a. m.; begin to run off, 8.15 a. m.; stand empty until 9.00 a. m., and so on until the evening, when the bed was run off at 8.15 p. m. and stood empty until midnight, and again was run off at 2.20 a. m. and stood empty until 6 a. m.

I have not been personally responsible for the arrangement of the times of contact and aeration, otherwise I should have been inclined to try the effect of shortening the period of contact and lengthening the period of aeration. At the same time the highly satisfactory purification that has been effected shows that the empirical time table is a good one. It is, however, very important that the facilities for emptying a filter bed constructed similar to these on a large scale should be equally good, otherwise the lowest stratum of the bed would never get aerated and might conceivably become a breeding ground for anaerobes, which might undo some of the work done in upper parts of the bed and reproduce the odors and unstable compounds connected with the hydration instead of the oxidation stage of metamorphosis.

The Coke Filter Bed.—The general purification measured by albuminoid ammonia from this filter is given in Table 2. The action of this filter on the tank effluent is one by which not merely the average purification as measured by the albuminoid ammonia is greatly increased, but the range of variability about the mean is reduced both in absolute measure and as a percentage of the mean value.

Table 3 gives the differences from the averages during the successive periods of the extreme maxima and minima daily mean values of the albuminoid ammonia of the tank effluent and filtrate.

TABLE 2.—RESULTS OF SEVEN YEARS AND FOUR MONTHS' CONTACT FILTRATION SINGLE CONTACT THROUGH COKE BREEZE FILTER. ALBUMINOID AMMONIA: PARTS PER MILLION (DAILY MEANS).

Period.	No. of fills in twenty-four hours.	Days.	No. of samples analysed.	Gallons per cube yard.	Daily mean Tank effluent. Albuminoid ammonia. Parts per million.			Corresponding purifications on daily mean tank effluent in successive periods.	
					Average.	Max.	Min.	Max. t'k, %	Min. t'k, %
May 24, 1898, to Sept. 18, 1900	3	848	29	163	2.33	3.69 *F.0.96	1.24 F.0.56	74	54
Sept. 19, 1900 to Jan. 4, 1901	4	107	57	207	2.25	3.59 F.0.89	1.05 F.0.47	75	55
Jan. 5, 1901, to Oct. 2, 1901	6	270	166	337	2.33	3.73 F.1.25	1.06 F.0.48	66	54
Oct. 3, 1901, to July 24, 1902	4	204	102	211	2.90	3.75† F.0.90	1.24 F.0.60	76	51
July 25, 1902, to Sept. 17, 1904	3	724	111	149	2.48	3.80† F.1.10	1.60 F.0.60	71	62
Sept. 18, 1904, to Nov. 28, 1904	4	71	15	195	2.60	3.10 F.1.20	2.00 F.0.76	61	62
Nov. 29, 1904, to Sept. 18, 1905	6	294	75	272	2.93	3.40† F.1.26	1.40 F.0.72	63	48
General means or totals			555	219 average	2.54 average	True average by samples		68 mean	55 mean

*F. indicates corresponding filtrate.

†There were some higher figures in the tank effluents and filtrates in these groups, but they were so manifestly due to the abnormal presence of gas refuse that I have omitted them from being legitimate extremes. They are, however, included in the means.

TABLE 3.—WORKING OF COKE BED—FIGURES IN PARTS PER MILLION.

Period.	Daily mean tank effluent. Differences of extremes from averages. Albuminoid.	Daily mean tank effluent. Averages of periods.	Daily mean filtrate. Differences of extremes from averages. Albuminoid.	Daily mean filtrate. Averages of periods.
1	+1.36—1.09	2.33	+0.34—0.25	0.81
2	+1.24—1.10	2.25	+0.35—1.33	0.66
3	+1.40—1.27	2.33	+0.45—1.42	0.88
4	+0.85—1.66	2.90	+0.35—0.35	0.95
5	+1.32—0.88	2.48	+0.36—0.34	0.94
6	+0.50—0.60	2.60	+0.27—0.23	0.93
7	+0.47—1.53	2.93	+0.48—0.48	0.92
Averages	+1.07—1.16	2.54	+0.37—0.34	0.89

From this we may deduce the mean amplitude of variation of the daily mean tank effluent as 2.23 and of the daily mean filtrate as 0.71.

If the index of variability be taken as represented by the ratio amplitude of range to average we have

For the tank $\frac{2.23}{2.54}$ and for the filtrate $\frac{0.71}{0.89}$

and thus:

	Index of variability
Daily means tank effluent	0.88
Filtrate	0.79

and a reasonable expectation that a high albuminoid in the tank effluent will be reduced in a greater proportion than the 65 per cent given by the average daily means from the tank and filter, namely, 2.54 and 0.89 (albuminoid in parts per 1,000,000).

An inspection of the figures in table shows that this law is of general incidence. Thus the purifications corresponding to the maxima (daily mean) tank effluents are usually maxima, and corresponding to the minima (daily mean) tank effluents are minima, the reverse law applying more or less generally to the filtrates.

The average differences are, moreover, very similar, as shown in Table 4.

TABLE 4.—AVERAGES OF TANK TO FILTER PURIFICATION.

Daily mean tank effluents. Maximum.	Daily mean tank effluents. Minimum.	Daily mean filtrates. Maximum.	Daily mean filtrates. Minimum.
68%	55%	65%	53%

The lowest purification corresponding to a maximum tank effluent is 61 per cent. and the highest purification corresponding to a minimum tank effluent is 62 per cent.

The greatest exceptions to this rule appear to be those in Table 5.

TABLE 5.—EXCEPTIONAL RATIOS OF PURIFICATION.

Daily mean tank effluent.	Daily mean filtrate.	Purification per cent.	
2.80	1.40	50	Maximum filtrates of periods 4 and 7.
2.40	1.30	46	
1.47	0.33	77	Minimum filtrate.

For practical purposes it is only necessary to consider the maxima filtrates, from which it appears that a daily mean purification of over 50 per cent. can be relied upon for tank effluents above the average figure for albuminoid, and that with the Kingston sewage and tank effluent, and a filter of the relative dimensions, and of material similar to the one used in these experiments, the mean daily albuminoid figure will average 0.89, and very seldom exceed 1.25.

The number of deviations above and below the average have not been counted, but cannot differ largely owing to the approximate equality of the extreme deviations in Table 3. The number of negative deviations, however, is probably greater, and more so than might be inferred from the average deviations + 0.37 and — 0.34 owing to the fact that the average 0.89 includes some cases excluded from consideration as extremes owing to abnormal condition in regard to gas refuse.

The general balance may be seen from Table 5 where the averages are compared with the arithmetical means of the extreme values:

TABLE 5.—FILTRATE (DAILY MEAN).

Period	(a) Average.	(b) $\frac{\text{Max.} + \text{Min.}}{2}$	Difference. (a)—(b)
1	0.81	0.85	—0.04
2	0.66	0.67	—0.01
3	0.88	0.89	—0.01
4	0.95	0.95	nil.
5	0.94	0.95	—0.01
6	0.93	0.95	—0.02
7	0.92	0.92	nil.

The differences between the values for the calculated averages and those of the arithmetical means of extremes are remarkably small in all the periods.

The inference is that the occurrence of the extreme deviations is due to the operation of a law which operates more or less regularly and equally on both sides of the average and is practically independent of the rate of flow or the age of the filter.

The cases of extreme values in Table 6 exhibit the same tendency of the filter to generally exercise its maximum purification when most wanted, and its least when least so, and so be somewhat self-adjustive:

TABLE 6.—EXTREME RATES.

Cases.	Tank effluent.	Filtrate.	Purification.
Absolute maximum daily mean purification	2.69	0.49	84%
Absolute maximum daily mean tank effluent	3.80	1.10	71
Absolute minimum daily mean purification	1.13	0.65	42
Absolute maximum daily mean filtrate	2.80	1.40	50

The process of the average purification corresponding to the quantity passed through the filter in each of the seven periods may be realized from Table 7:

TABLE 7.—AVERAGE PURIFICATION.

Period.	No. of fills per 24 hours.	Average capacity filter.	Average flow per cu. yd.	Avg. purification upon tank effluent.
1	3	1,328 gal.	163 gal.	65%
2	4	1,265	207	71
3	6	1,372	337	62
4	4	1,288	211	67
5	3	1,219	149	62
6	4	1,120	195	64
7	6	1,107	272	64

Note.—Imperial gallons are referred to.

It will be seen that the purification reached a maximum in the second period of four fillings, and altogether averaged higher at this number than at any other. Also that while it fell somewhat at he first trial of six fillings, it maintained a high figure in the seventh period when six fillings was again tried. This may be partly due to the progressive reduction in the amount passed through owing to the reduction in capacity given in the average flow per cubic yard.

In order to give an idea of what may be termed the purification of the filter at each number of fillings, I suggest the following function which combines the flow and purification. The purification work may be defined as flow per cubic yard multiplied by percentage of purification, and I shall indicate this function by the symbolic "Flowpur." Thus if 219 represents the average flow for all the periods per cubic yard, and 65 per cent. is the average amount of albuminoid eliminated, or as it is termed the average purification, 219 × 65 ÷ 100 = 142.35, represent the average flowpur.

Treating the figures for the successive periods in this way we have the figures of Table 8:

TABLE 8.—FLOWPURS.

Period.	No. of fills in 24 hours.	Flowpur.	Time of each period.
1	3	106	348 days.
2	4	147	107
3	6	209	270
4	4	141	204
5	3	92	724
6	4	125	71
7	6	174	294

Since the flowpur varies according to the number of actual fills, in order to determine the progressive deterioration, comparison can only be legitimately made between the values for the flowpur at the same number of fills. Taking the various cases, and reckoning from the middle of each period, we have Table 9:

TABLE 9—REDUCTION OF FLOWPURS.

Period.	No. of fillings.	Reduction of flowpur.	Days elapsed.	Reduction per annum.
2 to 6	4	15%	1,286	4.25%
4 to 6	4	11	861	4.66
2 to 4	4	4	425	3.43
3 to 7	6	167	1,281	4.75

Owing to an alteration made in the top 12 in. of the filter in March, 1901, its capacity was somewhat increased artificially at the commencement of the third period, so that the figures 4.66 and 4.75 are probably the most correct. Taking the mean of these, which correspond very closely, the flowpur of the filter may be said to reduce at a rate of about 4.7 per cent. per annum, the actual amount being dependent on the number of fills found to be possible with a required degree of purification. The actual reduction in the water capacity of the filter from the third to the seventh period was equal to 19.3 per cent., which works out about 5.5 per cent. per annum.

The flowpur, therefore, deteriorates somewhat less than the actual water capacity, and therefore the purification power alone is well maintained. The reductions in both are small. A similar comparison of filters receiving a septic tank effluent will show a deterioration in or a loss of water capacity amounting to about six times as much as the above.

The Clinker Filter.—This has been worked somewhat similarly to the coke bed, except that latterly the number of fillings has been reduced to four per twenty-four hours, while those on the coke bed have been increased to eight. This has been done at the request of the Royal Commission, because the coke bed has consistently given better purifications, and in order to see how far the fillings could be increased when dealing with a tank effluent of this species without materially diminishing the purification.

Prima facie it was conceivable that part of the difference between the degree of purification attained by the coke and the clinker beds might be due to the actual difference in the two water capacities corresponding to the same surfaces, but the relation already found between the capacities and the purifications shows that this factor is either insignificant or indeterminate, since when the average flow per cubic yard in the coke bed is 163 imp. gal., the purification is 65 per cent., and when it is 336 gal. the purification is 62 per cent., or a drop of only 3 per cent. for an increase of 174 imp. gal., while for an increase from 163 to 207 gal. flow there is an increase in the purification of 6 per cent.

A detailed comparison of the clinker analysis has not been made, but for a period of two years a comparison of 106 samples taken under similar conditions has been made, which is given in Table 10:

TABLE 10.—COMPARISON OF COKE AND CLINKER FILTERS BY ALBUMINOID AMMONIA. (PARTS PER 1,000,000).

	Average tank effluent.	Average filtrate.	Purification.	Average flow per cube yard.
Coke	2.46	0.95	61	241*
Clinker ..	2.46	1.25	49	217*

* I am excluding the idea that the actual difference in the ratio of water capacities to surfaces could account for any material difference in the purifications.

Now, if the law which so evidently operates in the case of the coke bed holds for the clinker bed the purification for a flow of 217 gal. ought to some extent to be higher than for one of 149. Even if we take the most unfavorable view, and consider that the higher flow accounted partly for the lower purification in the proportion of 3 per cent. for 174 gal., we should only be able to account for 1 per cent. of the difference in favor of the coke.

It may, therefore, be safely concluded that the difference shown above has nothing to do with the difference of capacity and flow in the two filters, but is due to an actual physical, chemical or bacterial, or all three combined, difference in the action of the two filters upon the tank effluent of the Native Guano Co.'s process at Kingston-on-Thames, by which the coke bed exercises a purification of 12 per cent. more than the clinker bed.

The actual purifying work done by the filters measured in flowpurs during this period was: Coke, 90.89 flowpurs; clinker, 106.33 flowpurs; but there is little doubt that if the coke filter were of the same volume and water capacity as the clinker filter the differences in the flowpurs would have been the same as in the purifications.

The clinker filter has never shown in other periods any purifications at all corresponding to those of the coke filter. Consequently, I have confined myself in the present paper chiefly to a discussion of the results from the coke bed.

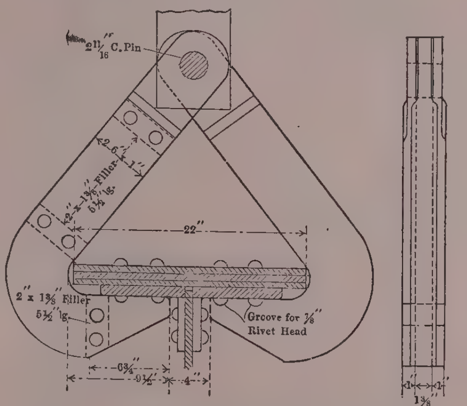
Water Capacity of Experimental Beds.—Owing probably to some obliquity in its dimensions, the absolute capacity of the coke bed has been always considerably less than the normal capacity of such beds from the very first. The water capacity of the clinker bed has, on the other hand, been normal. Thus the original water capacity of various similar beds at Manchester, Leeds, Leicester and London was on the average 49.5 per cent. of their empty capacity and progressively dropped thence to 28.4 per cent. of the empty capacity after 6.2 months when receiving settled sewage, and a mean of eighteen beds in various centers given in Dr. Clowes' report No. 679 yields an average of 45 per cent.

Similarly the Roscoe beds at Manchester, which were almost exactly the same dimensions as the coke and clinker beds at Kingston, 25 cu. yd., began with a water capacity of 1,750 imp. gal., which is 41 per cent. of the empty capacity.

At Kingston the linear dimensions of both the coke and clinker beds should have made their empty capacity equal to 24.4 cu. yd., or 4,125 imp. gal. As a fact their original capacities were 1,400 and 1,850 imp. gal. respectively for the coke and clinker beds; the percentages of their empty capacity being 34 and 44.7 respectively.

The exact cause of this remarkable difference has not yet been ascertained, but as soon as the present experiments which are being conducted on these beds at the request of the royal commission cease, the material will be cleared out, and the actual empty capacity remeasured.

The value for the clinker bed is normal.


2 11/16" C. Pin
2'-6"
1"
2"x 1 3/8" Filler 5 1/2" lg.
22"
2" x 1 3/8" Filler 5 1/2" lg.
Groove for 7/8" Rivet Head
6 3/4"
9 1/2"
4"
1"
1"
1 3/8"

20-Ton Hooks for Handling Girders. Quebec Bridge.

In estimating the relative loss of capacity little error will be introduced; and the rate appears to be almost identical for either filter, as shown in Table 11:

TABLE 11.—REDUCTION IN WATER CAPACITY OF THE COKE AND CLINKER BEDS.

Coke bed. Year.	Capacity. gal.	Clinker bed. Year.	Gallons.
1901, March ..	1,420	1902, July 7....	1,850
1901, October ..	1,324	1903, October 17	1,700
1903, October ..	1,129	1904, Nov. 11..	1,690
1904, Nov. 9...	1,190	1905, Dec. 1....	1,355
1905, Nov. 9...	990	1906, Feb. 22...	1,346
1906, Feb. 22...	817		

These give a total average decline in capacity per annum of 8.5 per cent. with the coke bed and 8 per cent. with the clinker bed. A similar comparison of the alterations of capacity of the Roscoe beds at Manchester shows a decline of capacity amounting to 10.7 per cent. per annum of original water capacity. These may be taken to represent the rate of loss of capacity of coke beds after a good chemical effluent has been passed on, the small loss being evidently connected with the small amount of suspended matter.

A DOCK CUT FROM SOLID ROCK has recently been completed at Port Florence on Lake Victoria Nyanza, Africa, at an altitude of 3,800 ft. above the sea level, and probably the highest navigable waterway of any magnitude in the world. The dock, which accommodates the Nyanza fleet, operating in connection with the Uganda R. R., is 48 ft. wide, 250 ft. long and 14 ft. in depth and was excavated out of solid rock by native labor at a cost of $20,000, requiring twelve months for completion.

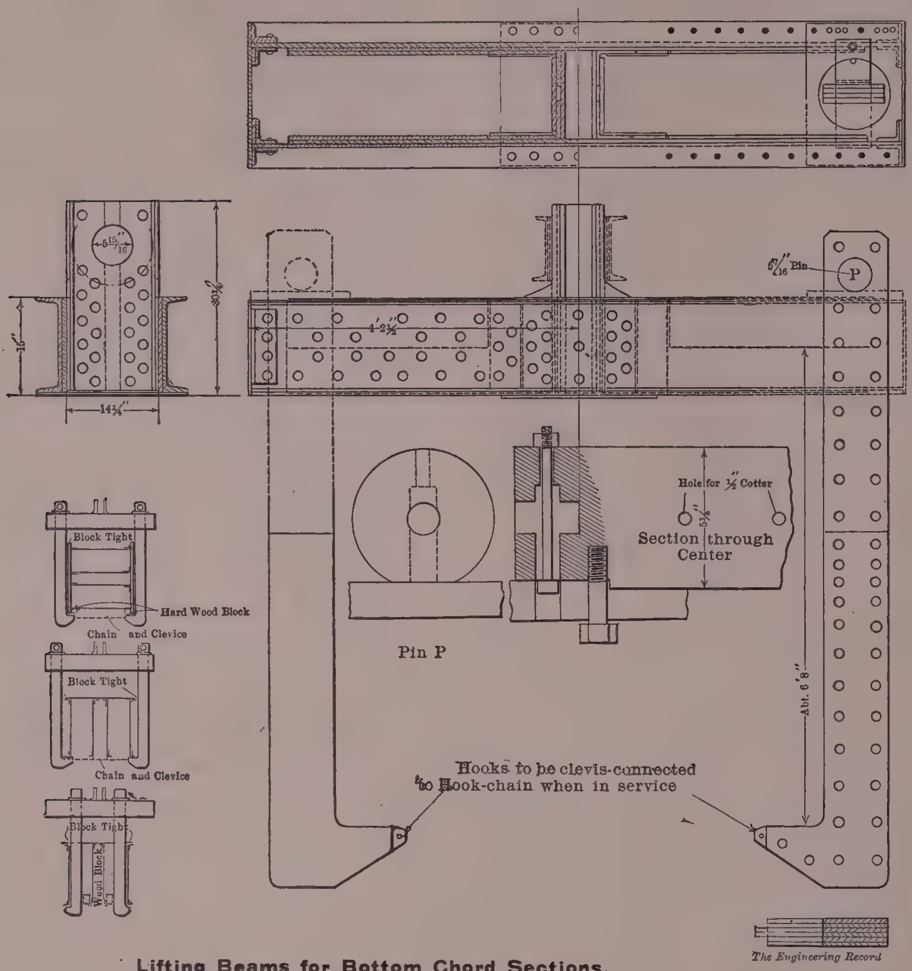
Handling Members in the Erection of the Quebec Bridge.

All the material for the south half of the Quebec bridge is handled from the storage yard at the south end of the bridge with a capacity of about 15,000 tons, which has been found not too large to accommodate the train loads of material already shipped from the bridge shops. The yard covers an area of 68x750 ft. at about the level of the bridge floor. Two longitudinal standard-gauge tracks run through it, one of them receiving cars from the bridge shop and the other extending about 3,500 ft. where it forks into two branches which connect with the material tracks 41 ft. apart on centers, running across the anchor arm. The yard is commanded by two 60-ton girder cranes of 68-ft. span with a clearance of 30 ft. above the ground which load and unload all material from the center track where it is received from the shops and sent out to the erectors. The cranes were made by the Phoenix Iron Co. and are each equipped with General Electric motors having maximum speeds of 15 ft., 100 ft. and 200 ft. per minute for hoisting, traversing and locomotion, respectively. A general view and description of the runway girders was published in The Engineering Record of March 4, 1905.

The accompanying view of the storage yard is made from a photograph taken May 6, 1905, and shows members for the anchor span assorted and piled in the sequence required for erection. They are delivered to the bridge by an electric locomotive and 15 steel flat cars and are unloaded from them by tackles suspended from the steel traveler. As all of the principal members are of great weight, some of them exceeding 100 tons, special tackles and attachments are necessary for handling them and great care has been taken in their design and construction by the Phoenix Bridge Co. The tackles have capacities varying from 10 to 55 tons each. The twelve 10-ton tackles, so called, have a calculated capacity of 11 tons and are rove with 1½-in. Manila rope. They have triple blocks made with wooden webs and steel straps. They have 11-in. sheaves with self-lubricating bearings on a 1¼-in. axle and have an ordinary clevice connected to the straps with a 2-in. pin. Each block weighs about 260 lb. The 17-ton tackles have quadruple blocks weighing about 400 lb. each and rove with 1¾-in. Manila rope. The sheaves are 12½ in. in diameter and the clevices have forked ends distributing the shear on the 2-in. pin. The 22-ton tackles have quadruple blocks weighing 585 lb. each, rove with 2-in. Manila rope. They are fitted with 14-in. sheaves and also have forked clevices.

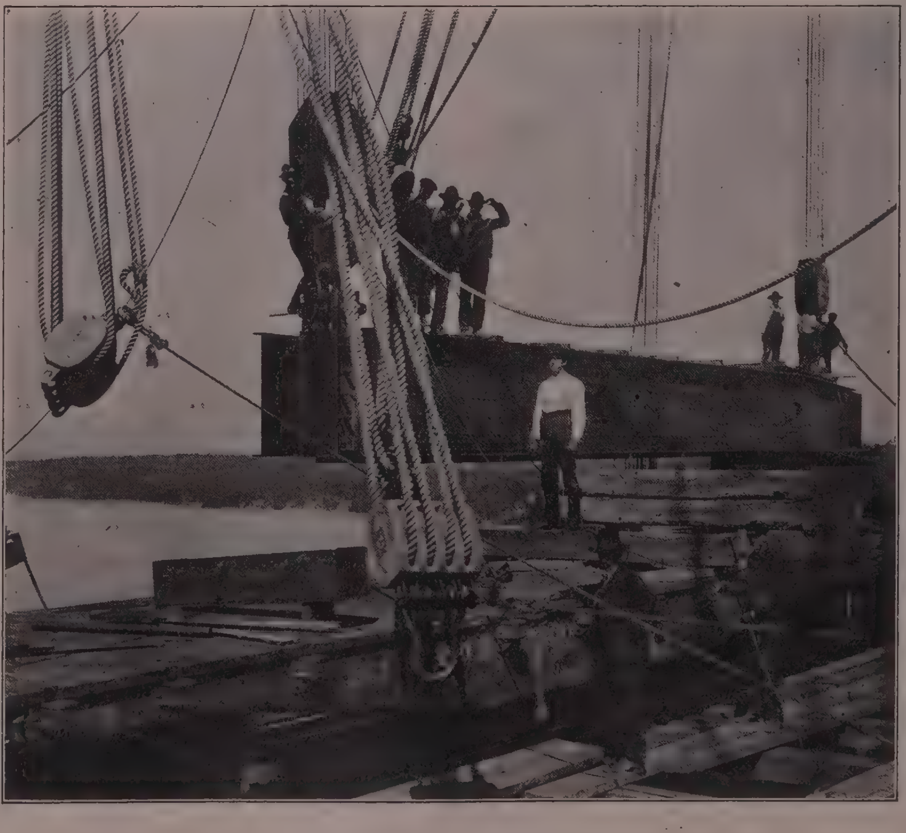
The 55-ton tackles each contains nearly a mile of ⅞-in. plow steel cable rove in nine parts through two quadruple blocks made with steel sheet plates and having forked clevices similar to those for the lighter tackles. The cast-iron sheaves are 23½ in. in diameter and weigh about 141 lb. each. They are bushed with phosphor-bronze and metaline rings made by the North American Metaline Co. They have a solid web ⅞ in. thick, a hub 2 7-16 in. thick and are bored for a 2 7-16-in. pin. The sheaves for snatch blocks are similar, but heavier, weighing about 176 lb. each. The upper blocks have forked clevices made from steel 3 in. in diameter bent to an inside radius of 4½ in. and weigh complete about 2,140 lb. The lower blocks correspond essentially to the upper blocks except that the clevice is at the lower end and that the cheek plates are longer than those of the upper blocks, projecting below the sheaves far enough so that the cast-iron filler plates between them increase the weight of the block to 3,545 lb.

The floor beams and stringers are handled by special pairs of hooks of a capacity of 20 tons each. One hook of each pair is made of a solid 6x2-in. bar engaged between the two 6x1-in. bars which form the other hook. The points of the hooks are grooved to clear the rivet heads on the under side of the flange and thus insure against slipping. A special set of hooks of 60 tons capacity is used for handling miscellaneous materials in the storage yard. It is designed to handle bottom chords, vertical and inclined posts and is made adjustable so that the hooks can engage the outside or inside of the webs. The hooks are pivoted at the top to adjust them automatically to slight variations from the vertical and to provide uniform bearing under all circumstances. They have a solid rectangular cross-section made of six 18 and 20-in. plates ¾ in. thick, riveted together. The upper ends pass between the webs of a box girder and engage special 5½-in. pins, flattened on the lower side where they are seated on bearing plates to which the pins are secured by means of vertical tap bolts. The bearing plates are movable on the girder and can be bolted to its top flanges at different points to provide for different spacing of the hooks. Short vertical diaphragms at the center of the girder project above its top flanges and are bored to receive a pin which connects it either directly to the hoisting tackle or to one end of an evening girder as the case may require. When the hooks engage the chord or post on the outside, the lower ends are connected by a short chain with clevice attachments and with a hook and turnbuckle to adjust it in the center. When they are used between the webs the backs of the hooks are blocked against the inner webs. This arrangement provides a safe and very rapid method of handling heavy members in any position and has been found very satisfactory in service.



Lifting Beams for Bottom Chord Sections.

Mr. E. A. Hoare is the chief engineer and Mr. Theodore Cooper consulting engineer, of the Quebec Bridge Co. The contractor for the steel work and erection is the Phoenix Bridge Co., Mr. David Reeves, president; Mr. John Sterling Deans, chief engineer, and Mr. A. B. Milliken, superintendent, and Mr. G. A. Tretter, assistant superintendent of erection.



Unloading Bottom Chord Section of Quebec Bridge with Special Yokes and Steel Tackle, Aug. 8, 1905.

How Should Steam Coal Be Purchased?

By William M. Booth.

The refinements of modern manufacturing require close adherence to fixed standards. Many of these are chemical, and others physical. The manufacture of steel, itself a fundamental industry, is carried on with great accuracy and uniformity of output through tests based upon chemical analysis, while the cement industry is equally exacting regarding crude materials, the product being tested largely from a physical standpoint. Other instances might be cited to show how valuable tests have become in connection with modern commercial affairs.

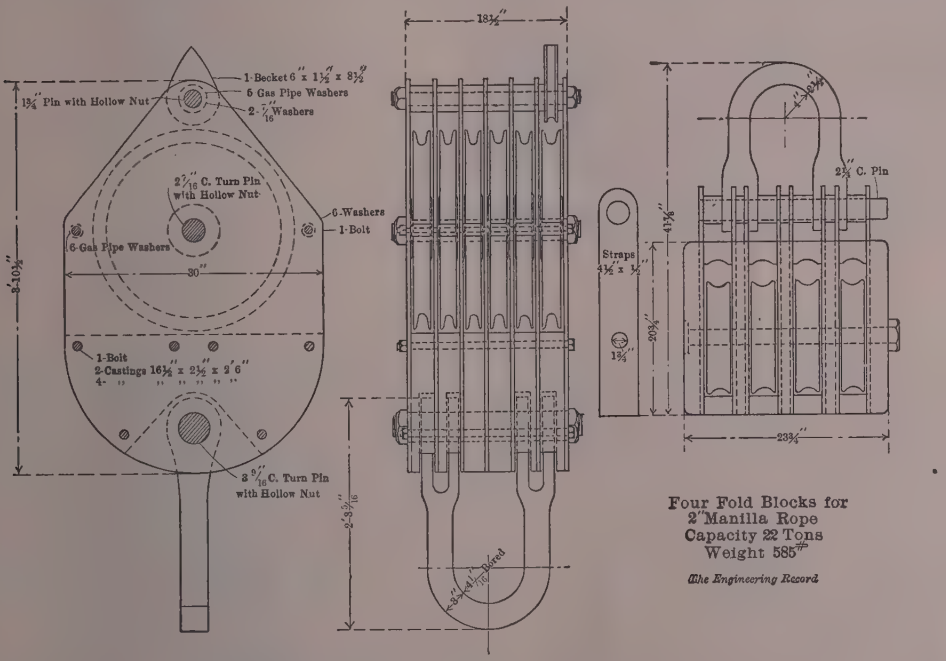
Of all the raw materials used by the average manufacturing concern, coal is one of the most important. The price and purity of this commodity at any given point often determine whether it will be possible to locate an industry. Peculiarly, steam coal has not been placed on anything like a uniform basis of purchase. Dealers are emphatic in denouncing any method of grading or analysis, and have discouraged purchasing on a scientific basis. That there is a tendency in this direction, however, it is possible to show.

The much used and practical method for the purchase of steam coal has been, and is, to try a sample of any given coal under the boilers. If efficient, large contracts may follow, extending from a few months to a term of years. When such tests are carried on under the supervision of a trained mechanical engineer and under as nearly as possible identical conditions nothing better can be asked by salesman or consumer. The evaporative effect measures the efficiency of the fuel for all practical purposes, and any competitive method for testing coal must be simple, less expensive and more definite in its results.

During the past thirty years expert engineers have run many tests with well known coals, establishing the reputation of those from certain districts, as for instance, Pocahontas or Westmoreland.

Manufacturing interests have largely increased throughout the eastern and middle states while the increased production of soft coal has not kept pace. The results have been disastrous in many particulars. The price has increased, much poor coal is on the market, and manufacturers have been compelled to buy from one broker to-day and from another to-morrow, in most cases glad to get any kind of fuel to keep their works running. Two years ago I asked a prominent coal dealer what he thought about tests in connection with the sale of coal. His answer was, "we sell all the coal that the shippers will send us, and our customers are glad to get it. Its purity is of no interest to us."

After visiting manufacturers I found their attitude to be different from that of the salesman, as one would naturally expect. They are getting many different grades of coal and are in some cases removing one-fifth of the material purchased in the form of ash and clinkers; while during the past year in the case of some industries it has been found impossible to maintain the proper steam pressure in the boilers with the grade of coal offered. Some time since a manufacturer using about a thousand tons of coal per year said that he had purchased twelve hundred tons of coal at a lower price than he had been paying, but as he was entirely ignorant regarding the constituents of this material he would like some kind of specification to aid in the matter of future purchases. Other users of steam coal admit a similar ignorance.



Four Fold Blocks for
2" Manilla Rope
Capacity 22 Tons
Weight 585#

The Engineering Record

Special Steel and Wooden Tackle Blocks.

The form of test first mentioned, that of evaporative effect, is seldom carried on under ideal conditions. The prevalent method has been to purchase a trial carload or several carloads of coal. The superintendent of the plant has then determined how this consignment compares from a standpoint of the amount used during a given period with that from other dealers covering a similar period. An authority on steam boilers says: "In practice, the physical character of the fuel, the form and construction of the boiler and furnace, the amount of air supplied and other conditions have an important influence upon general results. In fact the effect of these variables is such as to render accurate comparison of fuels a difficult matter." It may readily be seen that this may be an unfair method of treating the dealer, as firemen may be careless, prejudiced or ignorant, and "other conditions" may vary accordingly.

The particular coal in question, to be fairly tested, requires identical conditions regarding outside temperature, condition of boiler flues in reference to scale, method of firing, load and many other features only known to one trained through experience in such matters.

Some time since a prominent user of large quantities of coal received constant complaints from his firemen regarding the quality of fuel. A systematic series of tests was begun, when it was found that the ash varied from 10 to 14 per cent., and that the sulphur was rarely under 2 per cent. As a result of these tests a closely drawn specification was gotten up and a contract for the year's supply entered into.

As the subject seems to be a vital one, letters were written to prominent mechanical engineers, superintendents, purchasing engineers and others interested in coal from both the salesman and manufacturer's standpoints. Extracts from these letters are here included. Regarding the authority backing the statements made, it can only be said that it is of the highest and that these data were received with the understanding that opinions only be given. That these vary radically may be seen from the following:

"(We operate about forty mills.)

"If our coal gives us trouble we send a well mixed sample in an air tight can to the testing laboratory. The report of the chemist goes directly to the purchasing agent. We get on very well."

"Several mills in this section have fixed the ash limit at 10 per cent. and hold salesmen to this."

"We specify the ash limit at 7 per cent. and volatile hydrocarbons from 25 to 28 per cent. No attempt is made to follow the sulphur."

"My contract now calls for maximum ash at 4 per cent. and sulphur under 1.10 per cent."

"I believe that coal should be purchased by specification based on B.t.u."

"I am now preparing a graphic chart to aid our concern in determining the relative heating values of steam coal used. We buy by the carload from different sources and find it very difficult to obtain any kind of uniformity."

"The nature of our contract with the coal company furnishing us fuel, prohibits me giving you any information concerning the matter mentioned in your letter."

A well known mechanical engineer writes:

"In reply to yours of the 30th ult. to the writer regarding methods of buying coal, would say that we are unable to contribute anything of apparent value to this discussion. We have yet to be convinced that at the rate we are buying coal for an ordinary output of 750 to 1,000 boiler horse power we can do otherwise than buy on the basis of analysis of well known fuels, and trade with people in whom we have confidence. The conditions of purchase are such that analysis cannot be made of each individual car before dumping into our pocket, and therefore absolute control cannot be had over the quality purchased. Experience in many ways appears to be the best teacher, and honesty of a dealer the best assurance of satisfactory results."

From an authority on the subject of steam coal:

"Replying to yours of the 2d asking our opinion of the best method or practice in the purchasing of coal.

"1.—The best method is to test different coals in exactly the same manner and under the same conditions, and when the base is established, the same coal to be tested periodically during the life of the contract under the same conditions.

"2.—Make a comparison on the basis of proximate analyses and take into consideration the higher value of the fixed carbon as against the volatile, the difference in the composition from the standpoint of clinkers and ash.

"3.—Make a comparison on the basis of ultimate analyses.

"We consider these methods of value in the rotation that they are given."

From a large manufacturing concern:

"I beg to acknowledge receipt of your favor of July 30, in reference to methods used by this company in buying coal.

"As we have our own mines which supply us with all the coal that is consumed in the plant, we would not be in a position to give you any information that would be of interest on the subject on which you propose to write. It cannot fail to be of interest to a great many manufacturers, however, and you have my very best wishes for the success of your investigation."

"Replying to yours of July 30, regarding methods employed in buying coal, will state that we have so many different plants that it is difficult to give you any definite plan employed by us, owing to the fact that conditions vary at each plant. As a general proposition would say that we invite bids for furnishing us a given quantity of coal, and having found from test which gives us the best evaporating power, place our contracts with the lowest bidders, all conditions affecting the value being taken into consideration."

From the chief engineer of a large steel concern:

"Referring to yours of July 30th in reference to methods used by large corporations in buying coal, beg to say:

"As far as our company is concerned, we do not seem to have a very rational method of procedure here in this regard. In our estimation the price should be proportional in some way to the B.t.u. per pound, and there should be penalties for sulphur, ash and moisture; just how this should be applied, I am unable to say. This applies to boilers."

An expert in charge of a large number of mills:

"I regret to say that at the moment I cannot give you much help in regard to the practice of our company in purchasing coal, as we have not yet brought it to as good a system as you would like to have it. We began analyzing our coals a year ago and, as a result of our season's work, we have found out what mines to avoid in future purchases, and, in placing a number of our contracts, we have been able to hold people down to a minimum amount of ash."

"It is the writer's opinion that contracts should be based on the average composition of coal, based on careful sampling. The published analyses from the mines are very unsatisfactory and approach ideal rather than practical conditions. If we find, for instance, that coal shows an average analysis of, say 85 per cent. total combustible matter, and we get coal that only shows 80 per cent. combustible matter, we think the mine should stand the difference, assuming, of course, that 85 per cent. is the fair average composition of the coal."

"In all such propositions, the question of sampling is a highly important point, and unless fair samples are obtained, it is obviously impossible to do justice both to consumer and shipper. We have tried to follow the standard methods of sampling as much as possible, at our works, but I am very much afraid that prejudiced engineers and lazy firemen often make the sampling a mere farce. We hope to get this matter down to a finer point during the coming season, and after I get some results will be very glad to communicate with you further."

A concern using several thousand tons of coal daily:

"We depend upon tests of carload samples of the coal, making analyses and calorific determinations, and our contracts are made with the understanding that these tests shall be lived up to.

"There are no standard specifications, and each case has to be governed by its own conditions. We sometimes make special boiler tests to determine the practical efficiency of the coal in the evaporation of water under comparative conditions with another fuel we are using.

"For boiler fuel it is simply a question of the amount of water which can be evaporated for $1, taking into consideration all of the factors in the problem."

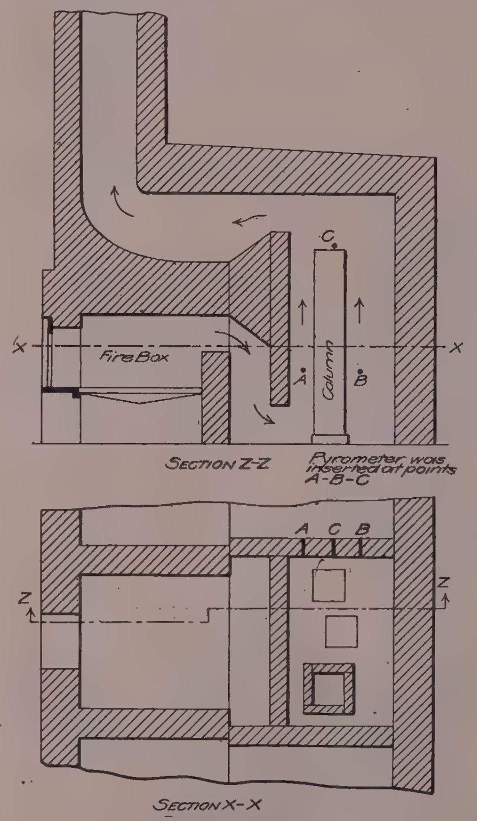
Regarding the specifications of a well managed railway: "All fuel coal has to be screened according to our directions either ¾ or 1¼-in., and must be reasonably free from slate and other products of the mine which are not combustible."

The specification of a certain municipal contract is as follows: "The class of coal which will be usually required at this station will be what is known to the trade as nut and slack, which is coal screenings resulting from the passing of a clean run of mine coal, of the grade required, over a screen having clear spaces of 1½ in. between the bars and nothing more.

Having these opinions from competent authorities the reader would judge that some uniformity should be followed in the purchase of steam coal. Actual test, chemical analyses and determination of heat units are used by different concerns with varying success.

Crude products used in large quantities are now sampled with great care. Iron ore may be mentioned as one of the most important. The composition of this material varies extremely, and yet its value depends on its primary constituent, iron, and the secondary constituents sulphur, phosphorus and silica. One would believe that coal should be considered in a similar way. Fixed carbon being considered the fundamental material with volatile hydrocarbons, ash, sulphur and water, the order in which they are mentioned. Finally, the B.t.u. should be accurately determined. The approximate average of a large number of analyses of coal shipped into central New York is as follows: Fixed carbon, 60 per cent.; volatile hydrocarbons, 29 per cent.; ash, 10 per cent.; moisture, 1 per cent.; sulphur, 2 per cent. The best coal shipped of which I have positive knowlege analyzed as follows: Fixed carbon, 70.01 per cent.; volatile, 26.27 per cent.; ash, 3.47 per cent.; moisture, .25 per cent.; sulphur, .86 per cent. That this coal has been stored for several months accounts for the very low percentage of moisture at 212° Fahr. One of the poorer samples of coal shipped to this section analyzed as follows: Fixed carbon, 52.16 per cent.; volatile hydrocarbons, 31.23 per cent.; ash, 16.10 per cent.; moisture, 0.51 per cent.; sulphur, 1.90 per cent. The highest ash of any sample of coal being 18 per cent., the highest sulphur being 5 per cent. and the highest moisture being 2 per cent. The B.t.u. per pound vary from 11,000 to 15,000. It is to be understood that these are all Pennsylvania or West Virginia coals which are supposed to be very much superior to those of Indiana or Illinois. The ash obtained has been the result in each case, of combustion in pure oxygen gas, thus giving the coal salesman the best possible end of the argument, as firemen are often liable to augment this percentage considerably through carelessness.

Regarding the constitution of the coal required for a particular boiler, it must be said that this may vary according to the amount of draft and method of firing. Coals containing above 35 per cent. hydrocarbons must certainly lose a large proportion of the energy of these constituents into the stack with considerable black smoke. On the other hand, coal that contains less than 25 per cent. of volatile hydrocarbons is not considered by some firemen equal to the demands of modern boiler practice for making a live fire. Sulphur is a poor fuel, as every mechanical engineer knows, and in addition, has a corrosive effect wherever its gases penetrate iron.



Furnace Used in Concrete Column Heat Tests.

The ash has been known to represent one-half the weight of the coal. However, a fifth or 20 per cent. would probably be high for coal shipped into New York state. This material must be removed, and certainly has a clogging effect which it is hard to overcome.

Regarding moisture, it may only be said that a high moisture coal is to be avoided. Coal that has traveled from 300 to 500 miles in winter through snow and rain would naturally be higher in moisture than that which has stood in bins for from six months to a year. If coal contains above 2 per cent. moisture, this factor might be an important one in its purchase compared with coal that is low in moisture.

It is to be understood that the analysis of coal is not as definite, nor is it required to be as accurate as that of high-grade steel, although an ultimate analysis of fuel can be made with great accuracy, and should be so made if the B.t.u. are to be reckoned in this way. If a specification must be used in the purchase of coal some provision should be made for a fixed amount of each constituent with a drawback if the composition of the material varies. If a sliding specification is to be used it ought to be elastic enough to give the dealer the benefit of the doubt, if he is doing his best to furnish a fair grade. For practical purposes with steam boilers it seems as though a coal of approximately the following composition ought to be fair both to agent and purchaser: Volatile hydrocarbons, maximum, 34 per cent.; fixed carbon, minimum, 56 per cent.; ash, maximum, 8 per cent.; moisture, maximum, 2 per cent.; sulphur, maximum, 2 per cent.

Many manufacturers tell me that they are able to follow the ash from the reports of the firemen but want to know in advance the average B.t.u. per pound of coal purchased. Formerly it was a very difficult matter to obtain a calorimeter of sufficient accuracy for anything like comparative results. This has now been overcome, and large users of coal can own a machine and test their purchases, or can obtain results from experts who make a specialty of this kind of work. The average of a large number of tests from Pennsylvania coal of the average grade is slightly less than 13,500 B.t.u. per pound. It would seem that 26,000,000 B.t.u. per ton ought to be a fair standard for the class of coals discussed. For those in the middle and western states entirely different standards will have to be established. It seems entirely unnecessary that a coal containing 16 per cent. ash should be shipped 500 miles, and that the consumer be required to pay for this material. With this number of heat units as a standard and a price agreement per ton for coal that averages as well as this, and with drawbacks for sulphur, moisture and ash, it would seem that a specification could be gotten up sufficiently binding and yet fair to all parties concerned. The analysis of coal is best carried on at the mine. The additional cost previous to shipment would then amount to but a small sum per ton. If samples are taken and analyses made by consumer or broker, the expense must amount to several cents per ton in hundred ton lots, but could be made insignificant in lots of several thousand tons, if careful sampling were resorted to. Coal purchased by specification and placed in storage in large quantity would bring the cost of sampling to a minimum.

Steam coals that have a similar general appearance may vary in value 35 cents per ton, and certainly not more than one-fourth of this difference should be paid for securing an analysis in small lots. With large quantities of coal the cost should be very much less. If purchasing by specification on large contracts with deliveries once or twice per month, samples from several cars could be mixed and analyses made from these samples. Purchased in single carload lots from different sources, coal could hardly be sampled properly without large cost. But as this is a hap-hazard method, it is to be discouraged on the part of any manufacturing concern.

This article is not written to support any conclusive statements regarding the subject, but has been prepared to bring forth discussion and to aid salesman and consumer in handling the fuel problem.

THE GREATER SAFETY OF ALCOHOL as compared with gasoline for commercial uses is due to the fact that it will not ignite from pure radiated heat as gasoline does; that water will extinguish burning alcohol while it will only spread a fire of gasoline, and that the flame of burning alcohol radiates very little heat while that of gasoline radiates heat very rapidly.

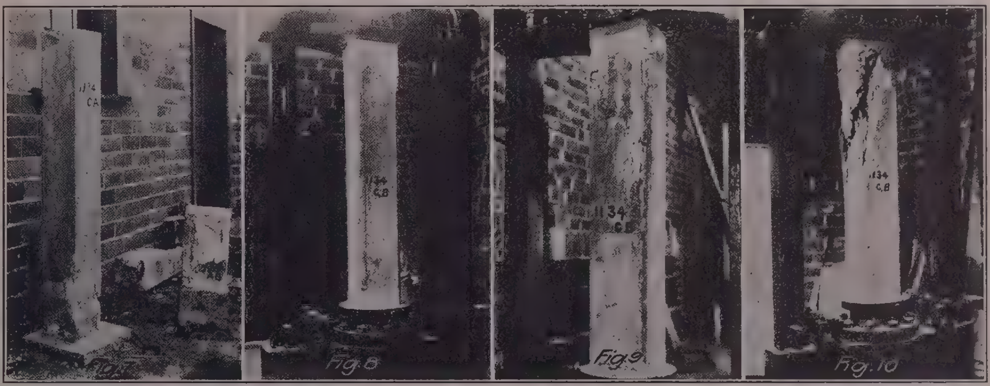
Heat Treatment of Reinforced-Concrete Columns.

By H. B. MacFarland.

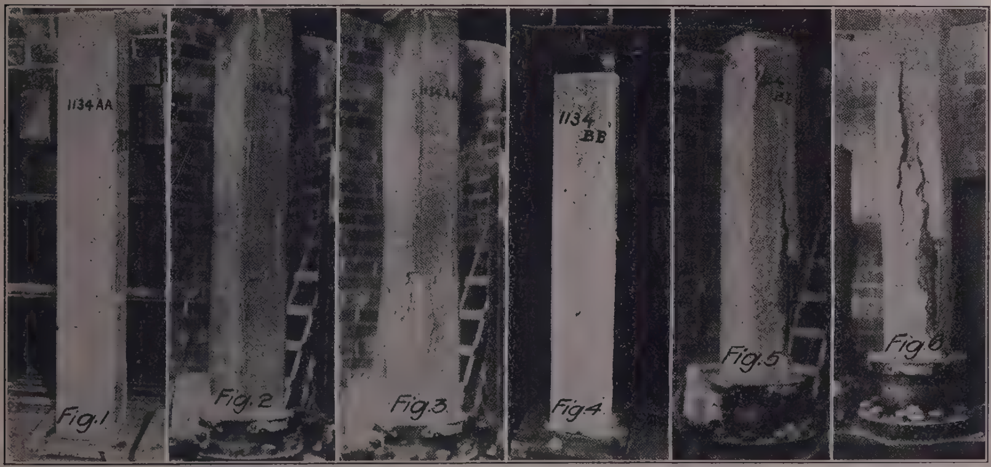
It is the object of this paper to present to the public the details of some interesting and remarkable experiments which were recently made at the Chicago laboratory of the National Fire Proofing Co. To Mr. E. V. Johnson, vice-president and Western manager of the aforenamed company is due the credit of conceiving these experiments and carrying out the details. The writer was asked, as a disinterested party, to conduct the heat treatment tests; on this account he will draw no conclusions but simply make a simple statement of facts.

The object of these tests was several fold: (1) To determine if a reinforced-concrete column when subject to a temperature of from 1,500° to 1,600° Fahr. for a period of three hours would be impaired in strength or elasticity. (2) To determine if possible the effect of quenching with water a concrete column which had been highly heated. (3) To show that a reinforced-concrete column encased in a fire-proof material is not impaired in strength or elasticity if subjected to a furnace temperature of 1,600° F. for several hours.

On Sept. 15, 1904, three reinforced-concrete columns were made. These columns were designated at No. 1134A, No. 1134B and 1134 C, and later when they were cut into shorter lengths a second letter was added in order to preserve the identity of the specimen. The original dimensions of the columns were 10½x10¼ in. by 12 ft. These columns were composed of a mixture of the following materials: One part of Owl Portland cement, two parts of sand, of which one-half was torpedo and the other half bank sand, four parts of ¾-in. limestone. The reinforcements consisted of a ⅜-in. iron rod 2 in. from either corner running the entire length of the columns.



Four of the Concrete Column Test Specimens.



Six of the Concrete Column Test Specimens.

When column No. 1134A was two months old it was subjected to a compression test and withstood a maximum total load of 77.5 tons; it gave way at one end. The column was left exposed to the weather and in August, 1906, it was divided into two portions, hereinafter designated as No. 1134AA and No. 1134AB, for further testing. The portion No. 1134AB was subjected to compression test on Aug. 14, 1906, and withstood a total load of 190 tons; that is, 3,558 lb. per square inch. The length of the specimen was 18 in. The character of its fracture is exhibited in Fig. 7.

The portion No. 1134AA, 6 ft. in length, was encased in solid porous tile 3 in. thick, set in cement with metal fabric in the horizontal joints and reserved for a fire test.

When column No. 1134B was three and a half months old it was subjected to a compression test and withstood a maximum total load of 113 tons, or 2,116 lb. per square inch. The result shows that as compared with column No. 1134A there resulted a 46 per cent. increase of the total load in a period of 1½ months from the time after the column was two months old. After the column was tested it remained exposed to the weather until August, 1906, when a portion 5 ft. long was cut off and subjected to a fire test. The portion is hereinafter designated as specimen No. 1134BB.

When column No. 1134C was 23 months old it was divided into two portions, hereinafter designated as No. 1134CA and No. 1134CB. The portion No. 1134CB was reserved for fire treatment. The portion No. 1134CA was put in the testing machine and withstood a total maximum load of 137 tons; that is, 2,565 lb. per square inch. A photograph of the specimen after test was taken is shown in Fig. 7.

Accepting the statement by noted authorities that there is no appreciable difference in the compressive strength of concrete columns centrally loaded of heights differing within ordinary limits, ranging, say, from 3 to 14 times the least lateral dimension, we may compare this result with those previously obtained from the 12-ft. columns. A comparison of results shows that in a period of 19½ months, after the column was 3½ months old, there was a 21 per cent. increase in total strength and in a period of 21 months, after the column was 2 months old, there was a 76 per cent. increase in total strength.

TABLE 1, CONDITIONS GOVERNING CONCRETE COLUMN TESTS.

No.	Origin.	Length.	Tested.	Age, months.	Temperature, Fahr. 3 hrs.	Max. load, tons.	Max. load lb. per sq. in.
1134A	Made Sept. 15, '04..........	12 ft. 0-in.	Load, Nov. 16, '04..	2		77.5	1451
1134AA	Cut from 1134A and fireproofed Aug. 3, '06................	6-ft. 0-in.	Fire, Aug. 14, '06..	23	1500° to 1600°		
			Load, Aug. 15, '06..	23		167.	3127
1134AB	Cut from 1134A, Aug. 3, '06..	1-ft. 6-in.	Load, Aug. 14, '06..	23		190.	3558
1134B	Made Sept. 15, '04..........	12-ft. 0-in.	Load, Jan. 3, '05..	3.5		113.	2116
1134BB	Cut from 1134 B, Aug. 3, '06..	5-ft. 0-in.	Fire and Water, Aug. 14,' 06....	23	1500° to 1600°		
			Load, Aug. 15, '06..	23		36.	674
1134CA	Cut from 1134C, Aug. 3, '06..	6-ft. 0-in.	Load, Aug. 6, '06...	23		137.	2565
1134CB	Cut from 1134C, Aug. 3, '06..	5-ft. 0-in.	Fire, Aug. 14, '06..	23	1500° to 1600°		
			Load, Aug. 15, '06..	23		38.	711

Since the height, 18 in., of specimen No. 1134AB is not at least three times as great as its lateral dimension of 10¼, the compressive strength of this specimen cannot be taken as indicative of the strength of the long columns. It is a matter of interest, however, to note that this specimen withstood a maximum load of nearly 28 per cent. greater than specimen No. 1134CA, although both were of the same age.

The results of all these tests show that all the columns were excessively strong, so far as compressive strength was concerned.

It was proposed that there be three specimens subject to a fire test. One specimen was to be enclosed in a fire-proof material, a second was to be subject to the direct heat of the fire, and a third was to be quenched with water for a period of five minutes after the fire test had terminated. The temperature of the furnace was to be maintained as nearly as possible between 1,500° and 1,600° Fahr. for a period of 3 hr. After the fire test the specimens were to be put in the testing machine and subjected to maximum loads to determine the reduction, if any, of their compressive strengths, as compared with companion specimens previously tested.

The furnace as shown in the accompanying plan and section was exceptionally well built of fire-proof material. The heat was obtained from wood as a material for combustion which accounts for the rapid changes of flame temperatures which occasionally amounted to as much as 150° within a minute. The distribution of the heat through the furnace and about the several columns was remarkably uniform. A sight hole at the back of the furnace allowed the even distribution of the heat about the columns to be observed.

The temperature of the furnace was measured by means of a Bristol electric pyrometer. The element was inserted in various positions in the furnace from time to time; the positions have been designated on the accompanying drawings as A, B and C.

The position A was at the base and in front of column No. 1134BB. The temperature here taken was that of the flame about 4 in. in front of this column and about 21 in. from its base. The position B was at the rear and at the base of the same column. The element measured the temperature 4 in. in the rear and 21 in. from the base of the column. The position C was on top of the same concrete column. The element was placed so that it laid on the top of the column and indicated the temperature of the concrete column itself after the furnace had been fired for two hours.

The fire was started at 3.15 p. m.; at 3.32 p. m. the flame temperature in position A was 1,500° Fahr.; the heating was kept up for three hours after this time. The temperature was recorded at one-minute or two-minute intervals, as was deemed necessary.

The results of this record show that the maximum temperature was about 1,900° Fahr., while the temperature was most of the time kept above 1,500° Fahr. and did not fall below 1,300° Fahr. The pyrometer was watched very carefully in order to direct the stoking of the fire so that an excessive temperature might never be attained. At no time did the fire ever get beyond control; slight fluctuations of the temperature, however, were inevitable. After the temperature of the furnace had remained above 1,500° for a period of three hours the fire was drawn and the side walls of the furnace were removed. Specimen No. 1134BB was subjected to a water test for a period of five minutes. Great care was exercised so that no water or steam came in contact with the other columns. City water was turned on the specimen, but the water pressure was slight.

When examined after the test visible cracks were noted extending lengthwise of the specimen and rendering it valueless as a column.

The specimens were allowed to cool slowly for twenty hours when they were removed to the testing room and the fire-proofing material was removed from specimen No. 1134AA. Fig. 1 shows the appearance of this specimen after the fire test. It presented a sound appearance and when struck with a hammer it rang firm and clear.

Fig. 8 shows the appearance of specimen No. 1134CB after it had suffered the fire test and was set up in the testing machine. When tapped with a hammer it sounded dead and gave no resonance whatsoever. It had to be handled with extreme care to prevent it from crumbling away.

The condition of specimen No. 1134BB after it had been subjected to both fire and water tests is shown in Fig. 4. When tapped with the hammer it sounded dead and disintegrated. When touched with the hand it shelled off as if it had been partially air-slacked lime.

These specimens were set up in a 340-ton hydraulic testing machine built by R. D. Wood & Co., Philadelphia, and submitted to compression tests.

Specimen No. 1134CB was 23 months old at the time of the test. On the previous day it was submitted to a fire test, being exposed to a furnace temperature of from 1,500° to 1,600° Fahr. for a period of three hours.

When the compression load was being applied it groaned and gave forth sounds indicating that its internal structure was being materially compressed. When the load was less than 5 tons the failure to hold indicated that its elastic limit had been passed. When the total loda on the column was 10 tons and the column was tapped with a hammer it sounded fairly good. The column withstood a maximum load of 38 tons, or 711 lb. per square inch.

Fig. 9 shows the condition of the column when withstanding the maximum load, and Fig. 10 shows its condition when crushed to destruction. There was no indication whatsoever of a bond between the concrete and the reinforcement. Any portion of the column could be crushed and ground up in the fingers. When the load was 25 tons the column had decreased 7-16 of an inch in length.

A comparison of the compressive strength of this column with its companion No. 1134CA which withstood a load of 137 tons, it is found that the decrease in strength due to the fire test was 72 per cent.

Specimen No. 1134BB was 23 months old when subjected to fire and water test. It had previously withstood a load test as a portion of specimen No. 1134B. When subjected to a compression test it behaved in all respects like column No. 1134CB. It withstood a total maximum load of 36 tons, or 674 lb. per square inch. Figs. 5 and 6 show its appearance after it had been tested to destruction.

Specimen No. 1134AA was 23 months old when submitted for final testing. As a portion of specimen No. 1134A it had withstood a load of 77.5 tons when its age was two months.

This column was enclosed in a 3-in. thickness of solid porous tile and submitted to a furnace temperature of from 1,500° to 1,600° Fahr. for a period of three hours. It was centrally loaded and withstood a total maximum load of 167 tons, or 3,127 lb. per square inch, when it gave way by sudden failure. No effect whatsoever upon the column was noticed until the load was increased to 140 tons, when there was a slight falling off of the gauge.

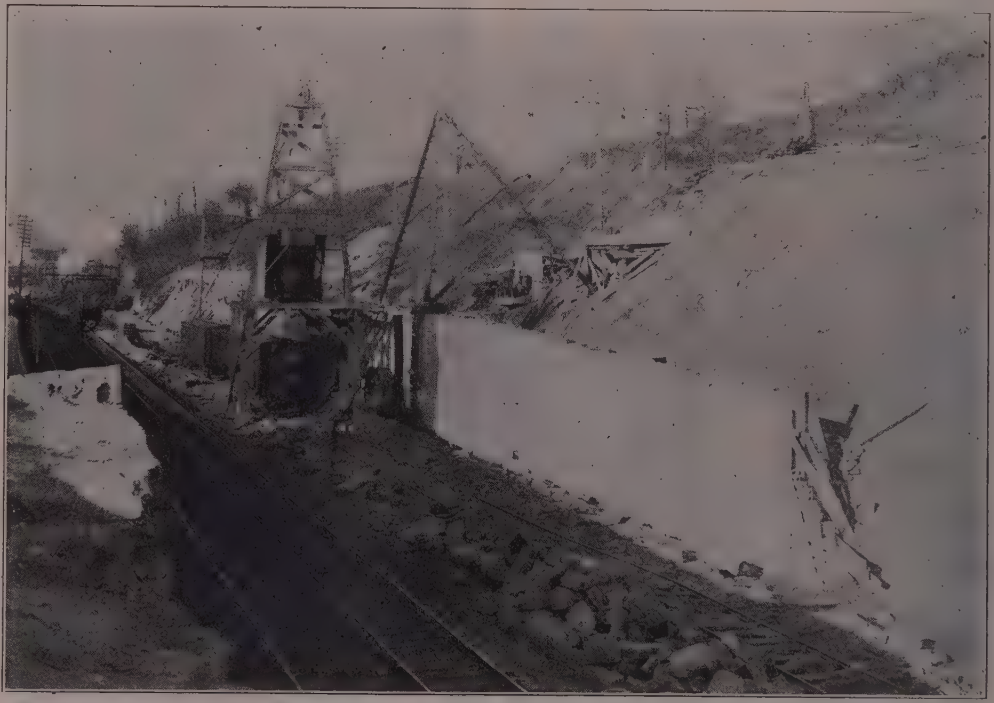
The results of this test could hardly be compared with those on that of its companion, specimen No. 1134AB, for the latter was too short a specimen in proportion to its least dimension to give proper results.

A series of tests are being conducted on the heat treatment of reinforced concrete beams and it is hoped that the results can be given to the public within a short time.

Laying Pipe Lines on Railroad Right-of-Way to avoid excessive franchise taxation in cities, has been resorted to by the Everett (Mass.) Gas Co. A franchise tax of $6,000 per year would have been imposed by that city upon new mains which the company was about to lay, and this was avoided by securing the rights to follow the line of the Saugus branch of the Boston & Maine R. R., from the company's gas plant to the points of supply. It is to be noted that an incidental economy was thereby secured, as the cost of construction of the pipe line on the railroad property was very much less than if it had been laid through city streets as it was originally intended.

Details of Construction of the Ossining Improvements on the New York Central R.R.

The electrification of the metropolitan zone of the New York Central & Hudson River R. R., and the simultaneous completion of the four-track system involved a large amount of improvement, construction and reconstruction at Ossining, N. Y., on the Hudson River, the general character of which was described and illustrated in The Engineering Record of March 3, 1906. Two old double-track brick-arch tunnels were removed and replaced by a single four-track tunnel of steel and concrete construction, a deep rock cut was made on the east side of the line to accommodate the two additional tracks, the original retaining wall there was removed and a much taller and heavier one of concrete, about 1,700 ft. in total length was built and some work was done on the original wall on the river side of the track. All of these operations have been conducted very successfully without any interference with the great volume of freight and express traffic and is now almost entirely completed, a force of from 50 to 150 men having been employed continuously there since the work was begun about a year ago. The principal quantities involved include about 10,000 cu. yd. of Giant Portland cement concrete and 50,000 cu. yd. of excavation and tunnel debris.

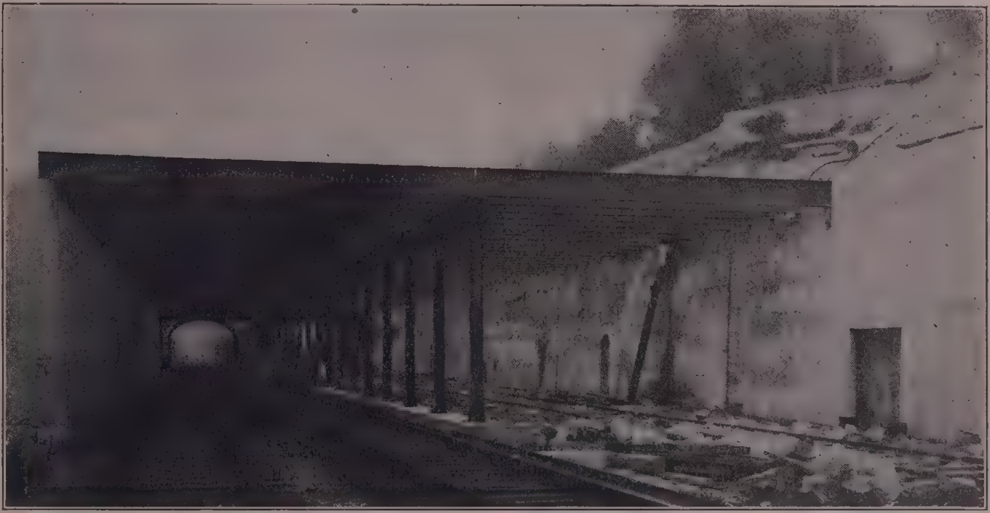


Cableway Tower Spanning Service Track.

Unusual care or special methods were required for nearly all portions of the work on account of the frequency of trains which during a large portion of the time passed at intervals of five or ten minutes, leaving in fact only two 30-min. intervals during the day when those portions of the work which demanded obstruction of the main tracks could be carried on. As described in the previous article, the contractors installed two longitudinal 800-ft. cableways in the cut over the centers of the new tracks to load the rock and earth on flat cars for removal, thus carrying on that part of the work independent of the main line traffic, but the necessity of blasting the stone with very small charges limited the rapidity with which the material was removed. The old tunnel structure was blasted and thrown down on the main line tracks in short sections and very hastily removed to the cut alongside where it was economical to rehandle it to the spoil cars in order to remove the obstructions during the very limited time that the tracks could be occupied. Derricks for this purpose were installed on the tunnel roof and other derricks were located on the top of the bank to handle the concrete materials for the new retaining walls and the tunnel.

A power plant and cable traction was established on the dock about 2,000 ft. from the center of the improvements and furnished air pressure for the rock drills besides providing for the delivery of concrete materials along the line of the work. It was found, however, that the cost of the extensions and elevations of this track finally became too great and its use was discontinued in the spring. The last 4,000 cu. yd. of broken stone were unloaded from the boats by a ¾-yd. clam shell bucket emptying directly into two-horse wagons. Some care was necessary to load the wagons, each of which held two or three buckets of material, but as the haul averaged over 1,500 ft. and less than one minute was lost in loading this consideration was trifling and the time was no more than was useful for resting the teams, three or four of which kept the bucket busy.

The wagons delivered on top of the bank close to the retaining wall and at a height of about 5 to 20 ft. above it. They dumped into storage piles located at short intervals along the line of the work and so arranged that the sand and stone were easily shoveled by hand into two Ransome concrete mixers set with their hoppers level with the surface of the ground. The delivery by wheelbarrows on top of the moulds described in the previous article was finally discontinued and the concrete mixers emptied their contents directly into one-half yard cyclopean buckets handled by the boom derricks and dumping wherever required in the moulds.



Roof Girders of Tunnel in Position.

Excavating for Two Additional Tracks.

The retaining wall had a maximum height of 31 ft. and corresponding width of 10 ft. base and a uniform width of 3 ft. at the coping. It was built as shown in the illustrations previously published with a battered face and an offset back with front and back forms, where it rose above the surface of the rock. As the proximity of the railroad tracks prevented external bracing of the upper parts of the forms, special provision was necessary for their stability and they were designed virtually as columns 10 ft. wide at the base and 31 ft. high. A template of the cross-section of the wall was erected and carefully lined up just beyond the end of a section to be built and a line of 3x8-in. full length vertical pieces 4 ft. apart on centers were first erected in the front of the wall and were secured by short inclined braces at the foot and by a few courses of the 2-in. tongue-and-grooved planed horizontal boards nailed to them for the face of the form. Vertical pieces 6 in. square and 8 ft. apart on centers were then set up in the rear face of the wall, often with their lower ends seated on the rock at a higher elevation than those in the front. They were temporarily braced to the rock or to the bank in the rear and were connected by the bottom courses of the horizontal face boards. In the middle of the second offset they were tied with four or five parts of No. 14 wire passed around them and around a 6x10-in. horizontal timber across the outer faces of the 3x8-in. verticals. The concrete was filled in permanently around the wires, the rear face of the form was braced against the 6x6-in. verticals and the wires were twisted until they produced a sufficient strain in the braces, keying the form tightly together and resisting the outward pressure of the concrete. A similar tie and correspondingly longer braces were provided in the next offset of the wall and so on to the top, thus making a simple and efficient construction for the forms which was found stable and satisfactory and was rapidly and economically built. The framework for a 50-ft. length of forms was set up in one-half day by a carpenter and three helpers who completed it, except for the upper courses of the face boards which were assembled as the wall was built up.

The wall contained 32 single lines of terra-cotta ducts in 18-in. lengths with their joints wrapped in burlap dipped in grout. These were set as the concrete was laid and the work was carried on continuously for each section of the wall from the time it was commenced until it was completed by a gang consisting of six wheelbarrow men feeding the concrete mixer, one cement man at the hopper, one man at the dumping chute, two men chaining cyclopean stone which were deposited in the forms by the derrick, one derrick man handling the concrete buckets, three men and a helper laying the ducts and three other men working in the forms who were assisted by the duct men after the latter had finished their work. Under favorable circumstances the best concrete record made was one 260 cu. yd. section of the wall 30 ft. high completed in 36 working hours. About 25 per cent. of the volume of the wall was made with a cyclopean stone which were produced by the excavation at the site. Expansion joints between the successive sections were provided by placing tar paper on the bulkheads at the ends of the forms and leaving it in position when the forms were removed, usually one day after the concreting was finished. No effort was made to handle the forms in sections as they were considered too large to make this method advantageous, so they were entirely dismantled and rebuilt for each section of the wall. Considerable loss was, however, experienced, by having a large amount of the boards and timber stolen notwithstanding the constant presence of one or two watchmen.

The steel framework of the tunnel consisted of a center longitudinal row of columns 12½ ft. apart on centers which supported a double line of 24-in. longitudinal I-beam girders carrying transverse 20 and 24-in. I-beams about 4 ft. apart seated at the opposite ends on the concrete side walls. The columns are entirely enclosed in concrete which is built up between them to make collision walls about 6 ft. high in four or five panel lengths separated by single open panels. The collision walls are reinforced by ¾-in. horizontal rods in both faces and column jackets above them are reinforced by expanded metal on all sides. The girders and beams are entirely enclosed by a monolithic mass of concrete forming the roof of the tunnel.

The steel framework was erected by the railroad company and the concreting was done by the contractors. The roof panels averaged about 4x30 ft. and were made with simple forms suspended with pairs of bolts from 4x4-in. wooden cross pieces on top of the transverse I-beams. The bolts passed through one-inch tin pipes which were permanently left in the concrete and allowed the bolts to be removed with the forms.

The tunnel roof was in most places nearly as high as the top of the adjacent bank where the concrete was mixed, as already described, for the retaining wall and was delivered in Ransome dump carts running on the tunnel roof to the required position. The collision walls were built in sectional moulds moved forward as the work progressed and used over and over again. The work on them and on the columns was considerably delayed by the passing trains. The column forms were made in two longitudinal halves yoked together and lined with thin sheet steel. The interior was cleaned and they were painted with paraffine oil each time before using. After the column forms were made an unexpected difficulty arose in filling them on account of the obstruction caused by plates on the bottom flanges of the girder which nearly closed the tops of the forms leaving spaces only 1 in. wide for filling them. As it was impossible to deposit concrete through such a narrow opening, the forms were filled instead with thin 1:3 mortar deposited through narrow flat funnels. The roof concreting was done by a gang of sixteen men who laid an average of 400 sq. ft. in ten hours. Eighteen duplicate panel forms were used and were generally removed when the concrete was 24 hr. old. This could only be done during the two daily 30-min. intervals between trains which would not afford time for taking them down and putting them up again, therefore it was necessary to lower them to the track, remove and store them and then erect them during the next interval, thus involving double handling and considerable extra expense.

In order to promote the handling of spoil cars in the new cut under the cableway, a special feature was devised by the contractors to facilitate continuous operations. The 45-ft. head tower of the cableway was raised 20 ft. bodily and seated together with the hoisting engine on the deck of a heavy well-braced timber tower about 15 ft. square set over the center of the standard-gauge service track and allowing clearance through it for trains and locomotives. The operation of the cableway was not interfered with and trains were able to run through the tower, an additional advantage being gained by locating the engine out of the way of the work in the cut. When it was necessary to move the cableway the cable was lowered from the top of the tower to the ground and a flat car was placed on the track under the center of the tower and the latter was jacked up from the floor of the car until it was about 1 ft. clear of the ground. The car with its load of probably 50 tons was then moved 500 ft. to the new location of the tower and the latter was quickly lowered to position, the cable restored to its top and the systems soon put in operation again.

Before the improvements here were commenced the tracks were crossed by a foot bridge of about 40 ft. span having two riveted steel trusses and a wooden floor about 40 ft. clear of the track. As the excavation of the double-track cut on the land side of the line necessitated the removal of the abutment on that side, that portion of the bridge over the new work was removed before operations were commenced and will probably be replaced after the completion of improvements by two spans supported on an intermediate bent. Two telegraph poles were delivered by the cableway under the bridge and were hoisted from it to a vertical position, braced and guyed. A transverse piece was bolted to them just below the bridge floor and the latter was tightly wedged up on it. The river end of the bridge was securely anchored, the trusses were then cut in two on the chord splices by cutting out the rivets and cutting the metal with a hack-saw. The floor was removed and the land end of the span was lifted bodily by the cableway and lowered to a flat car and removed. The cableway traveler was placed between the top chords of the trusses and was attached to the steel work by chains around both lower chords at panel points. The work is now completed with the exception of a portion of the tunnel roof and the retaining wall which it is expected will be entirely finished in October.

These improvements have been designed and supervised by the engineering department of the New York Central & Hudson River R. R., Mr. W. J. Wilgus, vice-president; Mr. W. H. Knowlton, principal assistant engineer, and Mr. C. K. Lawrence and Mr. T. A. Lang, resident engineers in charge. Messrs. Ford and Waldo, New York, are the contractors.

The Influence of Tamping on the Strength of Concrete.

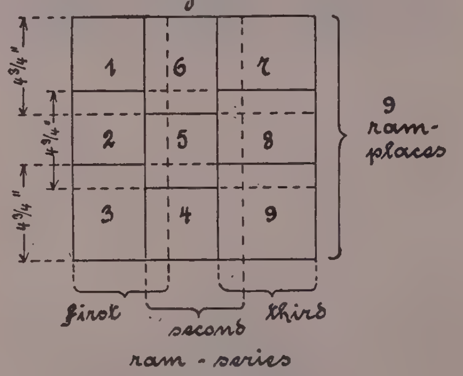
By H. Burchartz.

As requested by the Deutsche Beton Verein, tests have recently been made which give some explanation of the influence of tamping on the strength of concrete. The results of these tests have been made public and will, no doubt, be of general interest.

For the tests undertaken at three different places with the same material and on the same working principles concrete cubes of 30 centimetres (12 in.) were formed under application of 6, 12 and 18 tamping blows on the stamping place. The materials used were Portland cement from Dyckerhoff & Söhne, sand from the Rhine and from the Jsar River, and gravel from the same streams. The sand was sifted on sieves with square meshes 7 mm. wide.

The gravel consisted of pieces being separated on sieves with meshes from 7 to 20 mm. and from 20 to 40 mm. The concrete mixture consisted of one part of volume of cement and one part of volume of sand, and 8 parts of volume of gravel, of which 6 parts were 7 to 20 mm. and 3 parts 20 to 40 mm.

Fig. 1.



Method of Tamping.

In Biebrich the mixture was made on the Böcklin crushing mill, in Obercassel on the Hüser concrete mixer and in Karlshorst by hand.

Two different percentages of water were added, namely,

	Machine mixed. Percentage.	Hand mixed. Percentage.
Rhine sand and gravel:		
Dry mixture	5	5.2
Plastic mixture	6.5	6.6
Jsar sand and gravel:		
Dry mixture	5.8	6.0
Plastic mixture	7.3	7.4

of the weighed quantity of all materials contained in the mixture. The water already contained in these was determined beforehand and deducted. With the mixtures made by hand all materials were first mixed 3 times in dry state and then 4 times after being gauged with water, and readily worked through by iron rakes. In the machines the concrete was first mixed dry for half a minute, then wet for 2½ minutes.

The samples were made in two layers, so that each layer was divided in three tamping rows of 10 cm. width each, and each tamping place was treated by three blows, say 1, 2, 3 times forward and backwards; that is, 6, 12 or 18 tamping blows on each tamping place by allowing the stamps with a surface of 4¾x4¾ in. and 26 lb. weight to fall freely from a height of 24 cm. (10 in.).

The concrete mass was placed in two layers of about 18 cm. (7 in.) thickness each and after filling the mold a trowel was pushed down along the inner surface of same in order to press down any stones adhering to the surfaces of the mold and fill up with mortar any interstices between the stones. Before beginning with the tamping work the concrete mass was slightly pressed to-

Fig. 2.

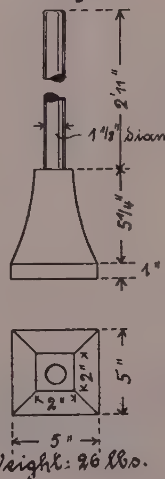
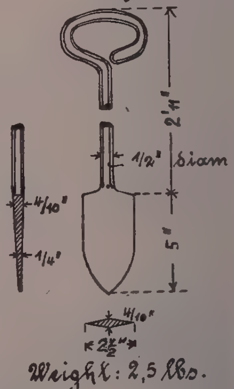


Fig. 3.



Tamping Tools.

Table I.

Weight of Volume and Compressive Strength. Averages of Five Individual Tests.

	Place of tests.		No. of blows.	Gravel from the Rhine: Wafer added, per cent.	Weight of volume, g/ccm.	Comp. strength at first crack, lbs. per sq. in.	Comp. strength at rupture, lbs. per sq. in.	Inc. of strength, per cent.	Difference bet. dry and plastic, per cent.	Gravel from the Tsar: Wafer added, per cent.	Weight of volume, g/ccm.	Comp. strength at first crack, lbs. per sq. in.	Comp. strength at rupture, lbs. per sq. in.	Inc. of strength, per cent.	Difference bet. dry and plastic, per cent.
Dry concrete	Bierbrich	Machine mixture.	6		2.354	2470	2680	—	—		2.402	1550	1860	—	—
			12	5	2.387	2940	3050	+16.4	—	5.8	2.427	2000	2140	+15.2	—
			18		2.390	2970	3210	+ 5.0 (Total +22.2)	—		2.445	2040	2270	+ 5.3 (+21.4)	—
	Obercassel		6		2.400	2680	2740	+18.1	—		—	1760	1800	—	—
			12	5	2.433	3180	3240	— 4.8 (+12.4)	—	5.8	—	2120	2220	+22.8	—
			18		2.452	2980	3080	—	—		—	2260	2370	+ 7.0 (+31.5)	—
	Karlshorst	Hand mixture.	6		2.309	1860	1930	—	—		2.320	1120	1120	—	—
			12	5.2	2.339	2140	2270	+17.7	—	6.0	2.389	1350	1360	+22.0	—
			18		2.326	2130	2230	— 1.9 (+15.5)	—		2.424	1410	1550	+13.5 (+38.5)	—
Plastic concrete	Bierbrich	Machine mixture.	6		2.393	1680	1950	—	—26.2		2.438	1550	1720	—	— 7.9
			12	6.5	2.399	1790	1870	+ 1.9	—35.4	7.3	2.454	1630	1770	+ 3.1	—27.4
			18		2.405	1790	2000	+ 1.3 (+ 3.2)	—37.6		2.369	1610	1790	+ 0.9 (+ 4.0)	—21.1
	Obercassel		6		2.426	1970	2130	—	—22.3		2.478	1820	1860	—	+ 3.1
			12	6.5	2.424	1990	2200	+ 3.3	—32.0	7.3	2.474	1820	1850	— 0.8	—16.7
			18		2.451	1890	2060	+ 0.6 (+ 4.0)	—28.1		2.470	1790	1800	— 2.3 (— 3.1)	—24.0
	Karlshorst	Hand mixture.	6		2.340	1750	1610	—	—16.8		2.444	1110	1140	—	— 1.7
			12	6.5	2.374	1800	1850	+15.0	—18.7	7.4	2.432	1080	1090	— 4.1	—20.1
			18		2.396	1820	1900	+ 3.1 (+18.6)	—14.5		2.436	1150	1180	+ 7.9 (+ 4.1)	—23.6

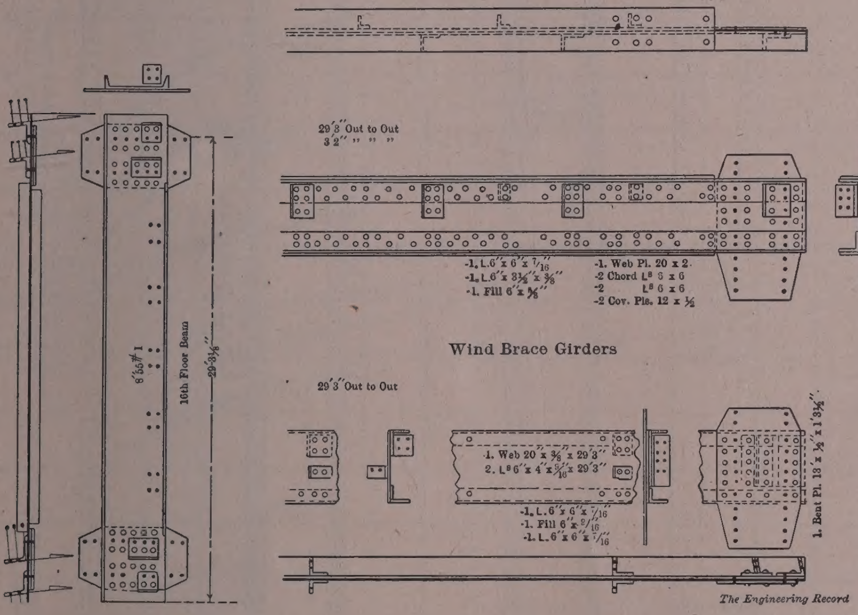
gether by the rammer. Before bringing in the second layer the upper surface of the first layer was roughened in order to obtain a good junction of the layers.

After finishing the tamping and removing the square frame the surplus concrete and the surface of the mass tamped in the molding frame was readily egalized and smoothened by means of a steel rule in order to get it quite plain. Hollow spaces were filled up by mortar of the remaining concrete mass.

The succession of the blows exerted is shown in Fig. 1, the shape and size of the rammer and trowel in Figs. 2 and 3.

The specimens made remained 40 hr. in the mold, being stored during the remainder of the time under wet sand. For each series of tests five cubes were made and pressed vertically to the tamping direction after 28 days on a hydraulic press.

The accompanying Table I gives the average results of these tests. The column showing the increase of the strength gives both the various grades of the ramming, also the total increase. It can be clearly seen from the table to what high degree the strength of dry concrete is increased by the ramming work, whereas with plastic concrete this influence is essentially lower. Beginning with a certain point this increase of strength of the concrete gives way remarkably, it finally even changes to a decrease of strength. The cubes, with a large addition of water, show a considerably smaller strength throughout than those with less addition of water. These tests also show the superiority of machine-mixing against hand-mixing.



Details of Wind Brace Girders.

Cutting Structural Steel Beams and Girders by the electric arc has been carried on in clearing away the debris and wreckage resulting from the fire at San Francisco, Cal. For this purpose a current of about 250 amperes, at from 90 to 100 volts, was supplied to the electrodes through long flexible cables, by a 25-kw. direct-current generator mounted on a truck and driven by a 40-h. p. single cylinder gasoline engine. The use of a voltage higher than that ordinarily used in the electric arc was found an advantage in that the arc is thereby rendered less susceptible to the influence of the wind. Remarkably satisfactory results were secured, a 15-in. I-beam being cut in two in about 20 minutes, whereas to cut a beam of this size with a hack-saw would have required several hours. This method of cutting is specially adaptable to inaccessible places.

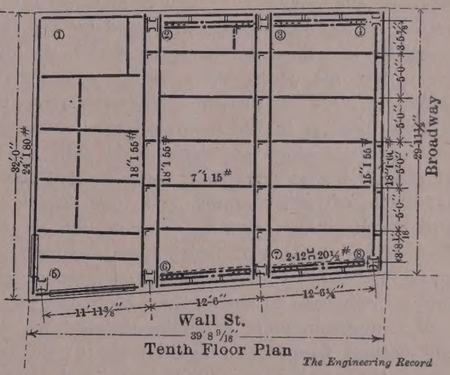
An Eighteen-Story Steel-Cage Building.

Several months ago much was made in the daily press of the sale of a small plot of ground at the southeast corner of Wall St. and Broadway, New York City, for an exceedingly large sum, said to have been a greater price per square foot than ever before paid for a building lot in New York City. Since that time the old buildings have been removed from the site and construction is now in progress of an eighteen-story steel-cage office building which will have a total height of about 220 ft. above the curb, besides a basement and cellar, and will have fronts of about 30 ft. on Broadway and 40 ft. on Wall St. The lot is not quite rectangular, so that the other two sides of the building have slightly different lengths. The basement and cellar will have their area almost doubled by wide extensions under the sidewalk reaching on Broadway to the walls of the rapid transit subway.

The upper stories will each of them occupy the entire area enclosed by the building and lot lines, the interior walls being built close against the walls of the adjacent buildings and no space being provided for an air shaft or light court as is generally customary between city buildings. The space is so limited and the horizontal dimensions are so small that light and air from the street fronts will penetrate the whole area and the elevator and stair shafts will be located in the rear, surrounded by a corridor from which all of the office rooms, fronting on the streets will be arranged. In some stories the entire floor will be occupied by a single tenant, so that the utmost economy in corridors and other public spaces can be secured. The cellar excavation is carried down to about ground water level and in it foundations are now being constructed with steel pipes driven by steam hammers to the bed rock at a depth of about 60 ft. below the curb. These are filled with concrete virtually becoming solid columns or piles, on the tops of which are seated grillages or distributing girders enclosed in concrete and forming, just below the cellar floor piers on which the entire building is supported. There are only eight main columns in the super-structure and these are arranged in two longitudinal rows, one row close to the Wall St. front and the other about parallel with it close to the walls of the adjacent building on Broadway. These columns are connected by transverse girders which straddle the columns and span the full width of the building, carrying all the floors, roofs, walls and contents of the buildings. This arrangement leaves the Broadway front entirely unobstructed, and gives only two intermediate columns besides the corner columns on the Wall St. front.

Three of the foundation piers on the Wall St. side are about 6 feet square, and are each made with a lower tier of seven 12-in. 35-lb. I-beams. The upper tier is made with three 20-in. 90-lb. I-beams transverse to them, all of them being connected with standard bolts and separators and enclosed in a solid mass of concrete. The pier at the rear end of this row is designed to distribute the load over a comparatively long distance at right angles to Wall St. and the grillage is made with a single tier having four 20-in. 90-lb. I-beams, two of them 9½ ft. long, connected together by full length 16x⅝-in. top and bottom cover plates virtually transforming them into a box girder. The other two beams 7 ft. long have similar flange plates and the column is seated on the center of gravity of the combined girders. On the opposite side of the lot the piers distribute the load over a comparatively long and narrow area close to the footing of the adjacent building. There are three piers, two of them carrying a single column each, are substantially like the one just described and the third one at the rear end of the row carries two columns one at each end and is composed of beams and cover plates like those described, which are about 17½ ft. long and 16½ ft. long, but differ from the others in that the cover plates do not extend the full length of the beams but are made in two comparative pieces for each flange, arranged symmetrical with the column centers.

The columns are all of simple construction with standard details and except No. 1, have rectangular closed cross sections made with two 15-in. channels and several 18-in. cover plates in the lower tiers and with 10-in. channels and 12-in. cover plates in the upper tiers. They are made in two-story lengths spliced with flange cover plates and butt joints 2 ft. above the levels of alternate floors. The splice plates are shop-riveted to the upper and field-riveted to the lower ends of the sections they unite. Column No. 3, in the middle of the row opposite the Wall St. front is typical of the other columns which vary from it according to the loads and to the beam and girder connections. The lower section of the column has a somewhat extended horizontal base plate stiffened beyond the column flanges by four vertical reinforcement angles riveted to the extended flange plates beyond the column flanges. Provision for slight adjustment is made by slotting the anchor bolt holes in the corners of the base plate. Pairs of vertical connection angles, ⅞ in. apart in the clear, are riveted to the column on the center line to afford field connection for the wall girders at the basement floor level. Above them field rivet holes through the flanges provide for the transverse girder connections.



Typical Floor Plan.

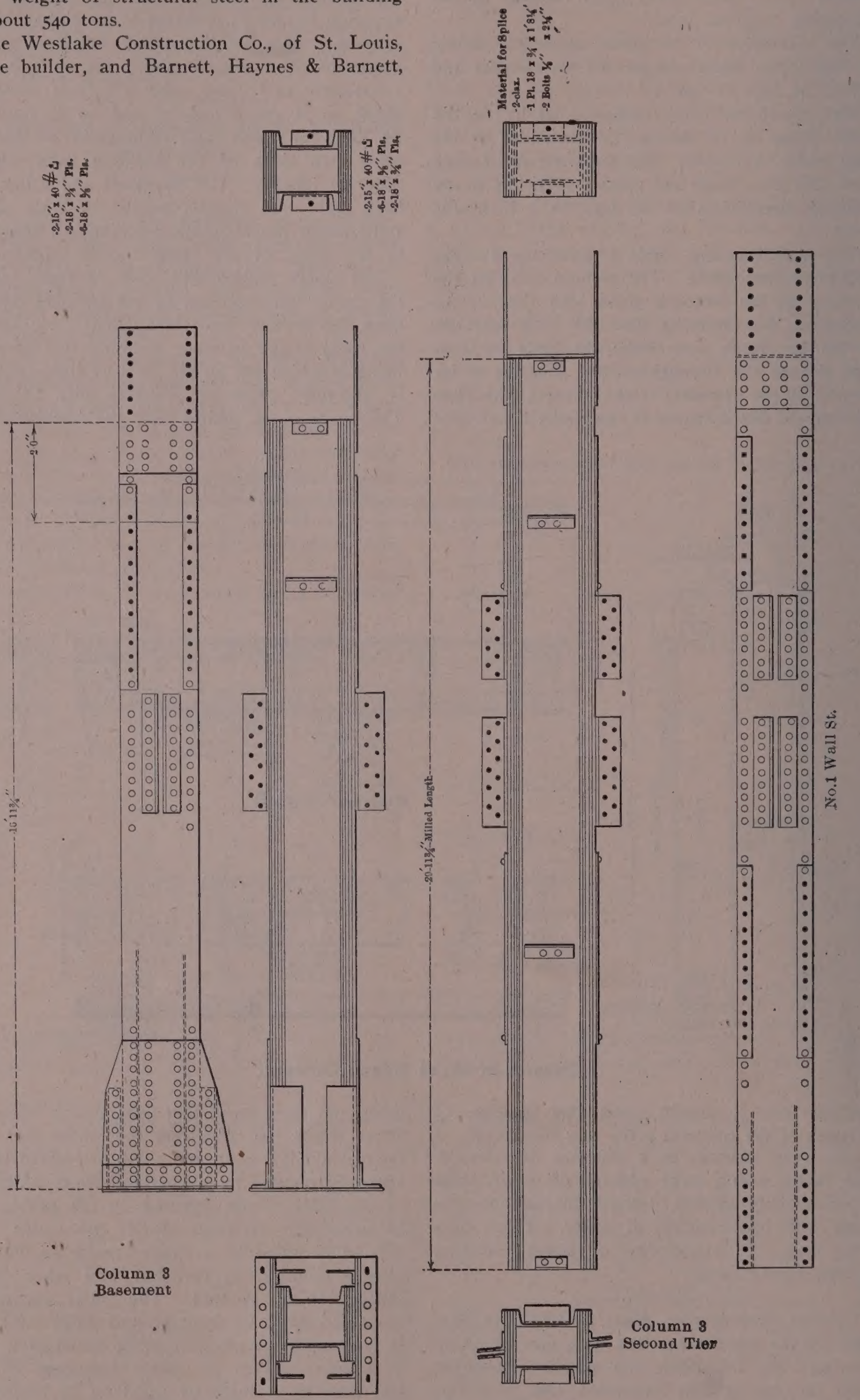
The second section of the column corresponds to the first, except for the omission of the base plate, and is a simple shaft about 30 ft. long with connections for the wall girders and floor beams as shown in the accompanying drawing. The third section reaching from the third to the fifth floors, the fourth reaching from the fifth to the seventh floors are similar to it and those in the upper stories correspond, except that the section of the column is reduced as the loads are decreased. Column No. 1 at the corner diagonally opposite the section at Broadway and Wall St. is made with two channels having their flanges turned in the same direction, two flange cover plates, two web reinforcement plates on one channel and two reinforcement angles riveted to the web of the other channel. In order to clear the stairway it is set with the web at an angle of 45 deg. with the building line, as shown in the floor plan.

In the first floor the two intermediate main girders each consist of a pair of built channels with a 20x⅜-in. web plate and two 6x4x9/16-in. angles. Each channel is continuous across the full width of the building and its web is field-riveted across both flanges of both columns. The transverse girder on the Broadway front corresponds to the intermediate girders, except that the web on the street side has four flange angles and top and bottom cover plates transforming it from a channel to a regular plate girder with I-shape cross section. The rear transverse girder is made with a single 24-in. 80-lb. I-beam. The floor beams are spaced from 5 ft. to 5 ft. 9 in. apart and are made with single I-beams from 9 to 18 in. deep, web-connected to the girders.

The second floor framing corresponds to that of the first floor except that the Broadway girder consists of one 20 and one 18-in. I-beam. The latter extending across the faces of both columns and the former terminating at the inner faces of the columns to which it is web connected. The wall beams and girders are substantially like those in the upper floors, the diagram for the tenth floor being substantially typical of all. The principal difference from the lower stories is in the main intermediate transverse girders which are each made with a pair of 18-in. I-beams with their webs riveted across both faces of both columns. The rear transverse girder connecting columns one and five in the first, second and third floors have a single 24-in. 80-lb. I-beam with the flanges sheared on one side at both ends to enable the web to be riveted to a connection plate extending beyond the top and bottom flanges and field-riveted to the columns, thus acting as a knee-brace and serving to stiffen the panels transversely. All of the other transverse girders are similar, varying chiefly in the column connections and in the depths and weights which diminish upwards to 18 in. for the intermediate beams and to 15 in. for the end beams in the top stories. This feature of the design provides very deep connections for the girders and allows the work to be well classified in the shops so that most of the machine work can be executed on the comparatively light horizontal members that are easily handled and so that if necessary they can be separated and permit the beams to be completely finished at the mills. At the same time the pieces are all shipped complete and danger of losing or misplacing a large number of small separate pieces is greatly reduced.

Each tier consists of a simple arrangement of plain heavy beams making a rigid structure easily fabricated at the shops, rapidly connected and providing a rigid super-structure. The spaces between the double beams forming the intermediate transverse girders are so great that the latter are assembled together with short lengths of transverse I-beams one size smaller than themselves riveted in position in place of the cast-iron separators and bolts often used. Their connections are made with single vertical angles, shop riveted to opposite sides of the webs at both ends, thus facilitating the insertion of the piece between the main beams and its revolution to position about a vertical axis without the necessity of springing or displacing the transverse beams. Almost the only details in the building which are special are the bent pieces necessary to connect all girders to column No. 1 at the corner diagonally opposite the street section. The total weight of structural steel in the building is about 540 tons.

The Westlake Construction Co., of St. Louis, is the builder, and Barnett, Haynes & Barnett, of St. Louis, are the architects. The American Bridge Co. is the contractor for the structural steel, which was fabricated at its Brooklyn plant.



Details of Typical Columns, No. 1 Wall St. Building.

The Great Western Ry. of England recently opened a new main line which shortens the distance from London to Exeter, Plymouth and the western districts by 20 miles and avoids a number of congested junction points. The new line is a 107-mile cut-off, which replaces 127 miles of the old route by a series of old branch lines that were reconstructed and connected.

Methods of Testing Metals by Alternate Strains and Thermic Treatment of Steels to Increase Their Resistance.

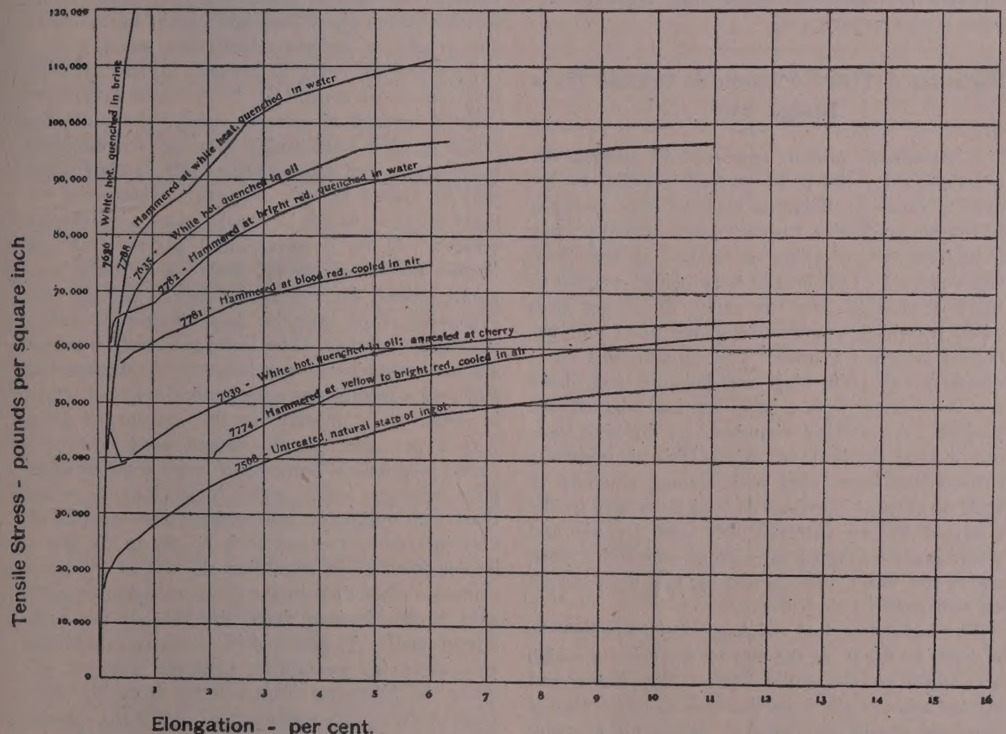
An abstract of a discussion presented before the Brussels Congress of the International Association for Testing Materials, by James E. Howard.

As interesting as it may be to ascertain the immediate physical properties, which may be acquired by means of changes in chemical composition or by modifications of heat or mechanical treatment, far more impressive are questions which pertain to the enduring qualities of steel and the definition of those conditions under which the metal will maintain its integrity unimpaired. The results of tensile tests, which so generally govern the acceptance of material, from the point of view of a repeated stress test can hardly be regarded as having but slightly further significance than the mere fact that the steel is possessed of certain properties as developed in that particular manner, without necessarily indicating in what degree those properties may be available for sustaining the varied service stresses to which the metal will subsequently be exposed.

TABLE 1.—TENSILE TESTS AND REPEATED STRESS TESTS ON DIFFERENT CARBON STEELS.

	Tensile tests					Repeated stress tests		
Description.	Elastic limit per sq. in. lb.	Tensile strength per sq. in. lb.	Elongation in 4 in. %	Contraction of area %	Mechanical work at rupture per cu. in. ft.-lb.	Maximum fiber stress per sq. in. lb.	No. of rotations at rupture.	Mech. work at rupture per cu. in. lb.
0.17 carbon steel......	51,000	68,000	33.5	51.9	982	60,000	6,470	32,835
						50,000	17,790	62,635
						45,000	70,400	201,960
						40,000	293,500	665,290
						35,000	5,757,920	9,992,390
						30,000	*23,600,000	*29,500,000
0.55 carbon steel......	57,000	106,100	16.2	18.7	1,047	60,000	12,490	63,387
						50,000	93,160	328,000
						45,000	166,240	476,900
						40,000	455,350	1,032,130
						35,000	900,720	1,563,125
						30,000	*19,870,000	*24,838,000
0.82 carbon steel......	63,000	142,250	8.5	6.5	888	60,000	37,250	189,044
						55,000	93,790	399,780
						50,000	213,150	750,465
						45,000	605,460	1,736,910
						40,000	*17,560,000	*40,973,000
						35,000	*19,220,000	*33,635,000

* Not ruptured.



Range in Tensile Properties of Steel from Same Ingot, due to Heat and Mechanical Treatment; Chemical Composition: Carbon, 0.20; Manganese, 0.58; Silicon, 0.015; Phosphorous, 0.017.

If, perchance, service conditions closely approach those which attend the tensile tests, such tests become reliable indices of quality, but such conditions, in a practical sense, are never present in the employment of the metal, and as the departure from them becomes wider there is a corresponding vagueness attaching to the application of the tensile results and their interpretation with reference to service requirements.

These remarks are exemplified in the case of steels exposed to repeated alternate stresses in which all grades of steel may ultimately be ruptured with scarcely a trace of permanent elongation or contraction of area, notwithstanding the metal in the original tensile tests displayed those features in a pronounced degree. Considered from another point of view, however, the steel, which under repeated stresses finally ruptured without permanent elongation, may have displayed a total elastic extension, the aggregate of successive strains, attaining a distance of several miles per linear inch of metal, but under tensile test the permanent elongation may not have reached the amount of ten per cent.

Nevertheless, the value of the tensile test is not to be underrated, and its importance is fully recognized in certain other specific directions. It cannot be dispensed with, but tensile results are not sufficient, as at present understood, to enable a satisfactory judgment to be formed of the value of the metal against sustaining repeated alternate stresses.

As above qualified, provided the repeated stresses approach the limit of tensile strength or are found in the vicinity of, but preferably in excess of, the tensile elastic limit, the comparative value of the steel against repeated stresses may in a manner be judged of, although wide divergences may be expected to characterize the results.

Repeated stress experiments were inaugurated in 1888 at the testing laboratory at Watertown Arsenal, Massachusetts, and have continued since that time. They have been made in a machine in which the shafts, 1 in. in diameter, 33 in. long between centers of end supports, and loaded at the middle of their length by means of a double bearing 4 in. apart on centers, have been tested. The speed of rotation in the apparatus in which they are tested is 500 per minute. There are two driving spindles on this apparatus, each of which accommodates two test shafts.

A third spindle is provided and was intended for the test of tubing, in which there were to be imposed longitudinal stresses of either tension or compression, in combination with the transverse loads. It has not been found practical to operate this spindle as intended, owing to inability to obtain tubular specimens of the required accuracy of shape.

Briefly mentioned the tests which have been made during the several years in which they have been in progress have comprised steels differing in chemical composition and representing different kinds of treatment; also, cast and wrought irons. The fibre stresses employed have extended over wide limits with different experimental shafts, and there are progressive series of loadings in several grades of metal.

Typical results are shown in Table I, in which are entered the results with three grades of steel, together with the principal features of the tensile tests of the same.

Since the time of compilation of the above table further work has been done on the several unfinished shafts, the results of which are given in Table 2.

TABLE 2.—RESULTS OF RECENT TENSILE TESTS AND REPEATED STRESS TESTS ON DIFFERENT CARBON STEELS.

Description.	Maximum fibre stress per sq. in. Lb.	No. of rotations at rupture.	Remarks.
0.17 carbon steel..	30,000	100,000,000	Not ruptured.
	35,000	6,470,460	Completed under this load.
0.55 carbon steel..	30,000	76,326,240	Loads alternated after 75,006,000 rotations under 30,000 lb. fiber stress.
	60,000	8,100	
0.82 carbon steel..	40,000	156,900,000	Still under test.
0.82 carbon steel..	35,000	93,598,900	Loads alternated after 62,076,660 repetitions under 35,000 lb. fiber stress.
	55,000	140,830	

The details of these and other repeated stress tests comprise deflection measurements of the loaded shafts and the sets developed at different stages. The greater number of the tests have been with shafts heavily loaded, thereby resulting in early rupture of the metal, the number of repetitions of stresses ranging from a few thousands to a few millions. But few experiments have reached 50,000,000 and upwards.

Having demonstrated the effect of comparatively high fibre stresses on the endurance of the metal, interest is next directed toward those shafts which have displayed the greatest endurance under given fibre stresses, and the definition of what maximum alternate stress may be endured indefinitely by any grade of steel, or for such as could be considered practically an unlimited number of repetitions. Furthermore, whether there is evidence pointing to the relative influence of the several properties developed by the tensile test from which the ultimate endurance could be judged of by reference to either of those properties. This involves a consideration of the question whether tensile strength, as such, has a marked influence on promoting the endurance under repeated stresses.

Inasmuch as examples may be conveniently found in the ordinary use of shafting and axles where the number of rotations reaches or exceeds 200,000,000, it can hardly be called unlimited endurance, in a practical way, unless the material is capable of enduring not less than this number.

It must be admitted that few experiments have been conducted of such duration as this. None of the Watertown tests have yet reached this number of repetitions. Preparations are being made for special tests in which the experimental shafts will be subjected to more rapidly applied stresses than usual, to enable a large number of repetitions to be attained within reasonable time limits.

Among the Watertown tests none are found which endured 100,000,000 repetitions of loads which were subjected to fibre stresses above 40,000 lb. per square inch, but under this stress some shafts exceeded 150,000,000 repetitions before rupture. A few shafts displayed exceptional endurance under fibre stresses even so high as 60,000 lb. per square inch, but the number of repetitions were not such as to make it convincing that a close approach to this fibre stress could be endured 100 or more million times.

Although these encouraging indications have been presented by a limited number of tests, conclusive evidence is still needed to show that the limit of indefinite endurance has reached the zone of 45,000 to 50,000 lb. per square inch fibre stress in the grades of metal thus far examined.

Respecting the influence of tensile strength upon the ultimate endurance of repeated alternate stresses, certain co-related data may be mentioned. The usual effect of overstraining steel is to increase the tensile strength in the direction of the overstraining movement. Such is the effect of cold rolling or wire drawing and the highest examples of tensile strength have been found in music wire in which the wire drawing was carried to an extreme degree. Tests of annular specimens, representing the outer and most strained parts of shafts which had been ruptured by alternate stresses, have in a number of instances displayed a tensile strength above the normal value. Furthermore, shafts which have been tested in the vicinity of 400 deg. Fahr. have displayed greater endurance than corresponding shafts tested at ordinary atmospheric temperatures. It will be borne in mind that steel at a blue heat possesses higher tensile strength than at atmospheric temperatures.

From these illustrations it might be inferred that the separation of adjacent parts of the steel in the act of rupture would take place only when the stress, locally reached, attained an intensity equal to the tensile strength of the metal. The introduction of internal strains in the steel by means of overstraining loads would favor the thought that rupture may be reached through the combined action of external forces, augmented by accumulated internal strains.

Against this conjectural explanation of the phenomenon of rupture, under a stress below the apparent tensile strength of the material, is the fact that occasional annealing of the metal has not prolonged the endurance of the steel. If rupture is approached through the aid of accumulated internal strains, annealing of the metal, which is known to relieve internal strains, might be expected to restore the metal to such a condition as would increase its endurance. The results of further tests are looked forward to with interest in this direction of experimental inquiry.

Since neither general elongation of the metal nor contraction of area is displayed by shafts ruptured by repeated alternate stresses, it is not clear how properties not developed may be expected to materially influence the results. In fact, the class of treatment which tends to increase the rigidity of the metal seems to add to its endurance under repeated stresses, rather than treatment which promotes elongation and contraction of area, since these features commonly gain as the elastic limit of the steel is lowered.

The tensile stress-strain curve is modified by overstraining the metal in a compressive direction. The opposite elastic limit has been found impaired by previous overstraining in the other direction, it being immaterial whether the overstraining occurred in a tensile or compressive direction. A temporary lowering of the value of the modulus of elasticity results from overstraining the steel. The effects of overstraining loads are found to remain in steel bars examined after the lapse of many years. Such considerations as those just enumerated tend to narrow the field of conjecture as to the immediate causes and mode of action whereby rupture is accomplished by means of repeated stresses without the display of those properties which are developed when rupture is reached in other ways.

Impending rupture seems to elude detection. The development of slight deflection sets in a rotating shaft may be taken to indicate that rupture will ultimately be reached under the load then acting, but the immediate approach of rupture is not always signalled by any peculiar behavior of the metal at that particular time. No modification or distinguishing characteristic has been found in the micro-structure of certain steel shafts after an exposure to 150,000,000 repetitions of loads, and which loads had caused rupture of the metal.

The accompanying diagram shows the results of a number of tensile tests on specimens from a low carbon ingot. These results were selected from a larger number of tests and grouped to illustrate the range of properties which may be displayed by the same steel, according to its method of treatment. The selected stress-strain curves occupy positions generally comprising that portion of the diagram which is above the curve representing the natural state of the ingot.

That the immediate tensile properties of steel admit decided modifications, these and other similar tests amply illustrate. To satisfactorily judge of the relation between these properties and the endurance of the metal under the action of repeated alternate stresses would seem to require direct experiments.

Righting a Tilted Pneumatic Caisson for a Bridge Pier.

A pneumatic caisson employed in sinking the foundation for the pivot pier of a swing bridge over a canal in Belgium was recently restored to the perpendicular without much difficulty after it had settled something more than 15 deg. from the vertical. The bridge was being erected to carry a railroad over the canal, the swing span of 86 ft. which was to rest on the pivot pier being its principal feature. The caisson, 26.5 ft. in diameter and 31 ft. high, was built of steel plates and was fitted with a steel cutting edge at the bottom. A working chamber, 7.5 ft. high, was provided at the bottom. Above this chamber the caisson had been filled with enough concrete to sink it, vertical openings having been left in the concrete for an entrance lock and for air and water pipes. Staging piles from which the work above the water was carried on had been driven on two sides of the caisson.

The canal bed had originally been dredged to a depth of 8.6 ft. at the site of the caisson which was close to the canal bank. The latter had eroded and the silt from the erosion had collected over the site of the caisson. When air pressure was admitted to the working chamber of the caisson this silt caused blow-outs under the cutting edge, with the result that the soil was loosened around staging piles. This occurred, according to a description of the work in De Ingenieur, after the caisson had sunk 4.5 ft. in the bed of the canal. When the air pressure in the working chamber had reached 1.2 atmospheres, the caisson commenced to tilt to the side where the ground had been loosened to the greatest extent and continued to move until it reached the total inclination stated. The depressed edge of the caisson sank to a depth of 9.75 ft. below the canal bottom, while the opposite edge remained in its normal position. The depressed edge was found to rest on a firm stratum of sand and clay, while the opposite edge was still in mud and silt.

A 1⅝-in. cable was attached above the water to the masonry in the caisson and extended 330 ft. to capstans and tackles anchored on the canal bank. The material under the high edge of the caisson was then excavated and removed from the working chamber through an ejector. At the same time a considerable pull was maintained on the cable. Under these combined actions the caisson soon started to move, rotating gradually about the high point of the cutting edge and finally resuming the site intended for it. As the masonry in the caisson was submerged after the righting was completed, the water was drawn down in the canal, and drained out of the upper part of the caisson, and the pier masonry completed in the dry.

Letters to the Editor.

MISTAKES IN WATERPROOFING.

SIR:—I have read with great interest the article on "Mistakes in Waterproofing," in your issue of Aug. 15, and Mr. F. S. Greene's comment on the subject in the issue of Sept. 1.

There can be no doubt that it is far easier to build waterproof walls, floors, cisterns and reservoirs of concrete than of any other building material, such as stone or brick. Cement has, in fact, for many years been resorted to as a means of preventing or stopping leaks in structures built of other materials. To be practically impermeable by water, concrete of cement mortar must, however, be made quite rich, especially if it is to be subjected to water pressure. With sufficiently rich mixtures, used throughout the walls or in form of plastering, it is undoubtedly possible to obtain water-tight work, or to repair any cracks or defects which may occur.

To close all voids in concrete by use of high proportions of cement is, however, a rather expensive method of water-proofing, and there are other ways in which this may be accomplished more surely and at lower cost. Mr. Greene states that he knows of only one truly waterproof cement mixture, which he speaks of as a hydrolithic cement. It is, however, well known that the Stettin Co., in Germany, makes a specially prepared cement for waterproof work, and our experiments show that this has remarkable water-resisting qualities. The company with which I am connected has for a long time manufactured and sold a waterproof compound, the use of which in concrete or mortar, to the amount of from 1 to 2 per cent. of the cement used, has been found in practical work on a large scale to make poor mixtures much more impervious to water than rich mixtures are without the compound. Our interest in the matter is chiefly in the possibilities it offers in extending the use of Portland cement, rather than in the comparatively insignificant profit obtained from the sale of the compound itself. As proof of its value as an addition to cement for waterproof concrete work, I will quote the following from a letter from Mr. Bertram Brewer, city engineer, of Waltham, Mass.:

"Results of the permeability tests of 8x8x4-in. concrete blocks subjected to 80 lbs. pressure.

GRAMS PASSING PER MINUTE (MAXIMUM FLOW).

14 days.	21 days.	28 days.	
5.52	2.92	1.91	Ordinary bank sand.
5.00	2.76	1.85	⅔ bank sand, ⅓ fine sand.
4.38	2.26	2.04	Bank sand + 2% compound.
0.20	0.16	0.18	Bank sand + 4% compound.

The Expanded Metal Fireproofing Co., of Chicago, wrote us Aug. 2:

"We give you below an extract from a letter from our foreman, under date of July 25:

"'We have been using this compound right along and have now used over two-thirds of the amount sent. We have had a number of very bad leaks in walls and corners and found it absolutely impossible to stop same with paper and pitch, but have succeeded in stopping them with this compound. We take a little clay or stiff mud first to stop the flow of water, then we use this compound mixed with cement and sand in about the following proportion: 1 pint cup compound, 2 gal. cement, 4 gal. sand; mixing the compound and cement thoroughly before adding sand. We have not found a leak yet that we could not stop with the above process.'"

Very respectfully,

Sandusky, O., Sept. 7. S. B. NEWBERRY.